Environment Canada   Environnement Canada

Recommendations for the design and operation of wood preservation facilities, 2004

Technical recommendations document

Report EPS 2/WP/6

Prepared for
Environment Canada
(National Office of Pollution Prevention)
and the
Canadian Institute of Treated Wood
by
G.E. Brudermann, Frido Consulting

Canada

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Ce document est également disponible en français sous le titre *Recommandations pour la conception et l'exploitation des installations de préservation du bois, 2004 : document de recommandations techniques.*

This guidance manual (also referred to as the 2004 TRD) may be cited as follows:

Environment Canada. 2004. Recommendations for the design and operation of wood preservation facilities, 2004: technical recommendations document. Prepared for the National Office of Pollution Prevention, Environment Canada, and the Canadian Institute of Treated Wood by G.E. Brudermann, Frido Consulting. Report EPS 2/WP/6. Available from Environment Canada, Ottawa. Binder and CD. 326 pages.

(It supercedes the five 1988 EPS reports [EPS 2/WP/1, EPS 2/WP/2, EPS 2/WP/3, EPS 2/WP/4, and EPS 2/WP/5] and the previous version of the binder of the same name that was published in March 1999.)

Cat. no.: En40-578/2004E
ISBN: 0-662-36697-2

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Contents of binder

Regulatory Note

Each wood preservation facility must provide the operators with the most recent labels for all registered pesticides used in the facility.

Pesticide labels are legal documents and must be complied with in accordance with the *Pest Control Products Act*. This includes adherence to use rates, directions for use, and usage of the personal protective equipment recommended on the label. Each facility is responsible for inserting a copy of the most recent label for each registered pesticide used within the facility into this manual. The pocket in the next page is provided for this purpose. Electronic copies of labels may be obtained at http://www.eddenet.pmra-arla.gc.ca/4.0/4.01.asp.

Recommendations for the design and operation of wood preservation facilities, 2004: technical recommendation document (2004 TRD), is a guidance manual that establishes best management practices (BMPs) for the design and operation of heavy duty wood preservation facilities. Its primary purpose is to establish benchmarks for design and operation that wood preservation facilities should strive to achieve. The recommendations in this guidance manual are consistent with good pollution prevention practices and environmentally sound management. Conformance with the manual should minimize the environmental and human health effects potentially associated with heavy duty wood preservation facilities.

The target audiences for this guidance manual are the owners and operators of wood preservation facilities and those who are designing new facilities or retrofitting existing ones. In many instances the manual contains general summary information on topics such as potential environmental and human health hazards and environmental effects potentially associated with exposure to these preservatives. Pesticide label compliance is essential to minimizing the risks associated with their use. This should not preclude the users of this guidance manual from obtaining other, more comprehensive information on these topics. This includes the regulatory documents published by Health Canada's Pest Management Regulatory Agency that outline the health and environmental risks of individual pesticides (http://www.hc-sc.gc.ca/pmra-arla/english/pubs/pubs-e.html).

This guidance manual has been designed to allow facilities to insert additional information, so that all information relevant to the design and operation of a facility can be found in one convenient location. For example, facilities are encouraged to keep recent copies of their pesticide labels in this binder. As information may change over time, facilities should ensure that all information is current. At a minimum, annual reviews of content by the facility manager or designated health and safety individual are recommended.

Relation to Federal, Provincial, Territorial and Aboriginal Regulations

This guidance manual provides the Best Management Practices for the wood preservation industry; it does not have regulatory authority unless a federal, provincial, territorial or aboriginal authority having jurisdiction has adopted its recommendations. Conformance with this guidance manual does not absolve a facility from its other legal obligations under the applicable laws and regulations of municipal, aboriginal, provincial, territorial or federal authorities.

Provincial regulation of heavy duty wood preservation facilities and industrial operations in general varies across Canada. Each facility should consult with all authorities that may have jurisdiction over it and its operations.

Pocket for pesticide labels

Please insert copies of the most recent labels for the registered pesticides used within your facility

Foreword

Wood exposed outdoors is subject to degradation by various organisms, including fungi, insects and marine borers. The impregnation of wood with preservative chemicals retards or prevents its destruction by these agents. By design, such preservative chemicals must be toxic to the target organisms. However, their use may also affect non-target biota and the environment, unless proper safeguards are taken. Like many other industrial chemicals, wood preservatives require proper handling to prevent hazards in the workplace and during transportation and storage, as well as to avoid emissions from the process and the treated product.

In 1984, Environment Canada, as part of a federal strategy to protect the environment and human health from potentially toxic commercial chemicals, evaluated use practices within the wood preservation industry. The department subsequently initiated a technical steering committee to develop technical recommendations for facility design and operations.

The objectives were to develop recommendations that would outline practices to:

- reduce or eliminate the release of wood preservative chemicals to the environment;
- minimize the exposure of workers to wood preservative chemicals.

The development process, which included the participation of representatives from federal and provincial government agencies, the wood preservation industry, forest industry labour unions, and workers' compensation boards, concluded with the publication of five technical recommendations documents (TRDs) in 1988 (1, 2, 3, 4, 5). The documents covered good practices for pressure treatment with each of the major wood preservatives then in use: chromated copper arsenate (CCA), ammoniacal copper arsenate (ACA), pressure treatment with pentachlorophenol (PCPP), thermal treatment with pentachlorophenol (PCPT) and creosote.

These documents have since been widely applied in Canada to the construction of new facilities and the upgrading of existing wood preservation plants. In addition, international technical guide documents for the preservation industry have made use of information contained in the Canadian TRDs from 1988 (6, 7).

The measures recommended in the 1988 TRDs were based on knowledge of the existing technology and the properties of the preservative chemicals at the time of their development. However, since the publication of the 1988 TRDs, a variety of new and modified operating technologies have been developed, environmental compliance criteria have changed, and knowledge of the properties of the chemicals has been expanded. Hence, it was deemed necessary to review the TRDs, update information where appropriate, and include any new technologies to take advantage of improved design and operational practices.

In response to the need to update the 1988 TRDs, Environment Canada and the Canadian Institute of Treated Wood (CITW) initiated development of a single revised TRD, which was published in March 1999(8). A review of the 1988 TRDs was organized by CITW and was undertaken by industry members. The industry comments were compiled by Frido Consulting. Relevant industry information, as well as additional information from the open literature or from experts and regulatory agencies, was also used to update the recommendations. The document underwent four draft stages, each entailing reviews and comments by industry, as well as federal and provincial regulatory personnel. It was finalized by a technical coordinating committee.

As indicated above, the 1988 recommendations were presented in five comprehensive documents. These have been found to be user-friendly in format and general content. However, there were many subjects and recommendations common to all, leading to duplication. To eliminate such duplication, the 1999 TRD included all preservatives and treatments in a single manual. Although the 1999 manual followed the contents and format of the 1988 TRDs as closely as possible, general background information and recommendations applicable to all preservatives were separated from information specific to individual preservatives. This structure made information about individual preservatives easier to find and facilitates additions of new preservatives and any other incidental information.

Following publication of the 1999 manual (1999 TRD) , the working group proceeded with a voluntary program to implement the recommendations at all wood preservation facilities in Canada. The goal of the program is to have all facilities conform with the intention of the TRD by 2005. To meet this goal, the TRD Implementation Program was developed with the following steps:

- Two rounds of information sessions were held across Canada to inform wood preservation facilities about the program.
- A baseline assessment, referred to as Assessment 2000, was conducted at every facility to determine conformance with the TRD.
- Each facility was required to submit an implementation plan by Dec. 31, 2001, which would describe how it intended to correct deficiencies from Assessment 2000.
- On Dec. 31 of years 2002 to 2005 inclusive, facilities are required to submit annual update reports to demonstrate continual improvement towards the 2005 goal.

- Random audits are conducted to determine whether the work conducted at facilities meets the intention of the TRD.

The program generated questions and additional knowledge regarding Best Management Practices. As a result, the 1999 TRD was revised and this updated document was published.

This updated manual, which maintains the format and content of the 1999 version, is meant to provide necessary information on the physico–chemical properties of the industrial wood preservatives. It includes new chapters on the preservatives alkaline copper quaternary (ACQ), copper azole (CA-B) and inorganic boron, which are newly registered in Canada. Ammoniacal copper arsenate (ACA) has been replaced by the new preservative "ammoniacal copper zinc arsenate" (ACZA). As well, the manual contains design and operational measures to enable safe operations in wood preservation facilities in terms of worker exposure and health risks as well as environmental impact.

The document is divided into three major parts: I **-** General background information and recommendations for wood preservation facilities, II - Preservative-specific information and recommendations for wood preservation facilities, and III - Appendices. Part I contains recommendations applicable to all currently used preservative chemicals. Part II includes specific recommendations for individual preservatives: these are supplementary to those made in Part I and must be used in conjunction with them. Part III contains a summary of the applicable legislation and space for additional documents.

The recommendations contained in this document may not be the only options available to attain the stated objectives. Alternative approaches may be equally effective or more suitable for site-specific conditions. When programs are developed for a particular facility, the recommendations provided may be modified if it can be demonstrated that an alternative approach, more suitable to the plant's conditions, would be equally effective in attaining the objectives. Although the recommendations do reflect currently available best practices, local regulatory authorities may want to deviate to accommodate local conditions.

The CD attached to the inside front of this binder contains a supporting document: "Technical guidelines for the design and operation of wood preservation facilities, 2004: technical guidance document." The technical guidance document contains detailed information and interpretation of general TRD requirements, which will help facilities to conform with the TRD. It also provides clarity, which will ensure consistency from facility to facility.

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Acknowledgements

The current update of this manual was jointly sponsored by Environment Canada and the Canadian Institute of Treated Wood (CITW). The guidance and assistance provided by the representatives of these organizations, C. Englot and H. Walthert, were greatly appreciated.

This manual is based and largely relies on the information contained in the preservative-specific TRDs issued in April 1988. Those documents were co-authored by Dr. D.E. Konasewich and Dr. F.A. Henning of Envirochem Services, whose excellent work is acknowledged.

Special thanks are extended to all CITW members and personnel from Environment Canada who reviewed the 1999 TRD and shared information on current industry practices, best management practices and best available technologies.

Part I

General Background Information and Recommendations

CHAPTER A

General Background Information and Recommendations

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1 The Need for Wood Preservation

1.1 Introduction

Wood preservation is the pressure or thermal impregnation of chemicals into wood to a depth that will provide effective long-term resistance to attack by fungi, insects and marine borers. By extending the service life of timber, wood preservation reduces the harvest of already stressed forestry resources, reduces operating costs in industries such as utility and railroads, and ensures safe conditions where timbers are used as support structures. In addition, a significant part of the treated wood volume is used for residential construction to improve the value of homeowners' investments and provide outdoor living space that is an essential part of the Canadian way of living.

The chemicals predominantly used in Canada for wood preservation are:

- aqueous formulations of arsenic, copper and chromium; borate; or copper, in combination with organic pesticides;
- pentachlorophenol in petroleum oil; and
- creosote and creosote/petroleum oil mixtures.

1.2 Wood Deterioration

Timber is subject to several types of deterioration following its removal from the forest. Wood-decaying fungi and insects drastically reduce the usefulness of unprotected lumber and other forest products. Decay reduces wood to its basic components: carbon dioxide and water. This may happen quite rapidly depending on the exposure conditions. As an example, untreated red pine posts were found to be serviceable for only 4.5 years, whereas creosote-treated posts lasted between 40 and 48 years under the same conditions (1). Similarly, railway ties used in North America would have an average life of five years without treatment, whereas treated ties under normal service conditions last in excess of 30 years. Protection is also needed against wood-boring insects. For example, termites are responsible for extensive damage to wood in storage and in service in southern Ontario and on the Pacific Coast. Marine structures, such as untreated dock pilings along North American coasts, can be destroyed by marine borers in less than one year. In contrast, properly preserved wood structures in marine waters are reported to perform for 30 to 45 years (2).

The main enemies of wood and the wood destroyers of greatest commercial importance are decay fungi. The growth of these fungi is dependent upon the temperature, moisture content, oxygen level and nature of the wood. Wood products, such as construction lumber, railway ties, bridge timbers, fence posts and utility poles, are usually in direct contact with moist soil or in locations where moisture collects and cannot readily evaporate. When there is no practical means of controlling the moisture, oxygen level or temperature, the options for the protection of such wood products are limited to the application of chemicals, which prevent fungal growth by making the wood unsuitable as a food source. Simultaneously, the treatment can also protect the wood from other wood-destroying organisms, such as insects and marine borers.

1.3 Wood Preservation Chemicals

The preservation of wood by chemical means can be traced back over 4000 years, to the time when the Egyptians apparently used bitumen to treat wooden dowel-pins in the stonework of temples (3). During the Roman Empire, tar, linseed oil, oil of cedar, and mixtures of garlic and vinegar were used for the preservation of wooden statues. Charring of wood surfaces and soaking in brine, alum, arsenic or copper salts were other methods used in Roman times and in the Middle Ages (4). Investigations to define alternative wood preservation agents were reported in the late 1600s. Efforts escalated during the 1800s, when economic considerations, prompted by the need for durable wooden ships and railway ties and trestles, spurred the search for effective preservatives and application methods (5). A review of the many chemicals and chemical formulations used historically and currently can be found in the above references and in texts such as those written by Hunt and Garratt (6) and Wilkinson (7).

Creosote and the full-cell treatment process have been used since the early 1800s, whereas the empty-cell processes were introduced in the first decade of the 20th century. Pentachlorophenol and the water-borne arsenical preservatives became of commercial significance in Canada during the 1950s and 1970s respectively. Current research has yielded not only modifications to existing formulations and treatment technologies but also the introduction of new preservative chemicals. The voluntary withdrawal of CCA from residential markets in 2003 prompted the introduction of new organometallic preservatives, namely alkaline copper quaternary (ACQ) and copper azole (CA-B).

The choice of wood preservatives depends upon the character of the wood to be treated, the anticipated service and the properties of the chemical or formulation. Wood preservation formulations must:

- protect against attacking organisms;
- be able to penetrate wood;
- remain in the wood for the length of the intended service;
- be chemically stable;
- be safe to handle;
- be economical to use;
- not weaken structural strength;
- not cause significant dimensional changes within the wood.

Other factors that determine selection of chemicals or formulations include fire resistance, colour or odour; paintability, corrosiveness, electrical conductivity and environmental considerations.

In Canada the predominant wood preservative chemicals or formulations in commercial use are:

- CCA (chromated copper arsenate). Major CCA-treated products include fence posts, foundation lumber and plywood, utility poles and construction timber.
- ACQ (alkaline copper quaternary). Major ACQ-treated products include lumber for patios and fencing in residential construction.

- CA-B (copper azole). Major CA-B-treated products include lumber for patios and fencing in residential construction.
- Borates. Uses are for wood components in interior applications.
- ACZA (ammoniacal copper zinc arsenate). Major ACZA-treated products include marine structures and construction timbers.
- PCP (pentachlorophenol). Major PCP-treated products include utility poles and cross-arms.
- Creosote. Major uses include treatment of railway ties, utility poles for export, and pilings and timbers for marine applications.

The development of alternative chemicals for wood preservation is the subject of ongoing research. The actual use of alternative chemicals will depend on industry and safety evaluations, and on approval under the *Federal Pest Control Products Act*, now administered by the Pest Management Regulatory Agency of Health Canada

1.4 The Value of Wood Preservation

A recent study showed that the Canadian preservation industry (8) in 1995 consisted of 64 active plants and treated about 2 million m^3 (70 million ft^3) of wood representing a value of $700 million. That wood volume amounts to 13% of Canada's lumber consumption and virtually 100% of Canada's pole production. Controlled studies have shown that wood preservation enhances the lifetime utility of wood by a factor of 5 to 10 or more, depending on the species, end use and efficacy of the treatment. If treated wood products had to be replaced by untreated wood, the annual Canadian log harvest would have to increase by 12.5%, which represents 66 million trees grown on 162 000 acres of boreal forest land. The total area of forest land required to sustain this level of production was estimated to be about 1.5 million acres, roughly the area of Prince Edward Island. This emphasizes the considerable contribution that the industry makes to forest conservation (8).

Substituting alternative materials (such as steel, concrete or plastics) for treated wood in industrial applications (not including residential) would incur increases in material costs to users of 100% to 200%, or $250 to $500 million per year, not including attendant cost increases in installation and maintenance (9). Such applications represent about 52% of total wood industry output.

Wood preservation also allows the more efficient use of the forestry resource by increasing the use potential of various wood species and the use of smaller and faster growing trees.

In 2000 a total of 67 plants operated in Canada. The product volume treated in 1999 was estimated at 3.5 million m^3 (122 million ft^3). It was valued at $724.6 million (10).

2 Overview of Wood Preservation Facilities

2.1 The Canadian Preservation Industry

There were 67 preservation plants operating in Canada in 2000 (10). Of these, 64 had pressure treatment facilities, two employed both pressure and thermal treatments and one used thermal treatment only. All except three plants used CCA. CCA was the sole preservative in 51 operations, while creosote and PCP were the sole preservatives in one plant each. Thirteen plants were involved in multipreservative operations: seven with CCA and PCP; five with CCA, creosote and PCP; and one with CCA, ACZA, PCP and creosote. One treated with borates exclusively.

Treatment plants exist in all provinces, except Prince Edward Island. The early plants were conveniently located to serve the railways. However, newer plants are concentrated in areas where there is great demand for consumer lumber, which represents more than 50% of the total industry output (9). The provinces with the most plants are Ontario, with 18, and British Columbia, with 16 (10).

2.2 Description of Current Plant Designs

2.2.1 General Plant Designs

Wood preservation plants generally consist of four components (9):

- yards for storage of untreated and treated wood;
- wood processing facilities (peelers, framing lines, kilns, etc.);
- impregnation facilities;
- offices, laboratory space.

The size of storage yards can vary significantly depending on the plant's treatment capacity and the manner of drying the wood. Air seasoning, which is generally used for poles, ties and large timbers, requires a large storage space. However, plants that process lumber particularly for the residential market may kiln dry or process wood under a "treatment service only" agreement, in which case smaller white wood inventory space is required. The storage cycle of treated wood is generally short, necessitating only a limited yard or shed area. Plants that provide storage for their customers, for example, the major railways and utilities, are an exception.

Wood processing equipment may include pole peelers, saws, framing lines, sorting tables, incisors, kilns, stackers and the like. Railway tie plants are equipped with special adzing, boring and incising machines.

The designs of impregnation facilities are specific to the treatment process employed and the preservatives used. A more detailed description can be found in the relevant preservative-specific sections. The following is a general description.

2.2.2 Preservation Processes

Preservation processes are aimed at injecting requisite amounts of preservative liquids deep into the wood to provide long-term protection against wood destroyers. In North America, the majority of preserved wood is treated by pressure impregnation processes. Thermal treatments are of secondary importance. The applied treatment parameters for all processes are limited by standards — in Canada, this standard is CAN/CSA 080 (11) — to ensure effective treatments without damage to the wood. Special requirements are contained in the *Best Management Practices for the Use of Treated Wood in Aquatic Environments* issued by the Canadian Institute of Treated Wood (CITW) (12).

Wood Conditioning

Before wood can be successfully impregnated with preservatives, the bark has to be removed and the moisture content reduced by a process involving drying or conditioning. This may be achieved by air seasoning, kiln drying or by a process carried out in the treatment cylinder, for example, a steam/vacuum process or boiling-under-vacuum (Boultonizing) in the presence of the treating solution. The method chosen depends on the wood product, specifications, the available equipment, desired moisture levels and the preservative used. For example, kiln drying is most common for lumber destined for the residential market; air seasoning is most economical for large commodities, such as ties, timbers and poles; a steam/vacuum process is preferred for poles to be treated with PCP/oil; and Boultonizing is common with ties and marine pilings to be treated with creosote or creosote/oil solutions.

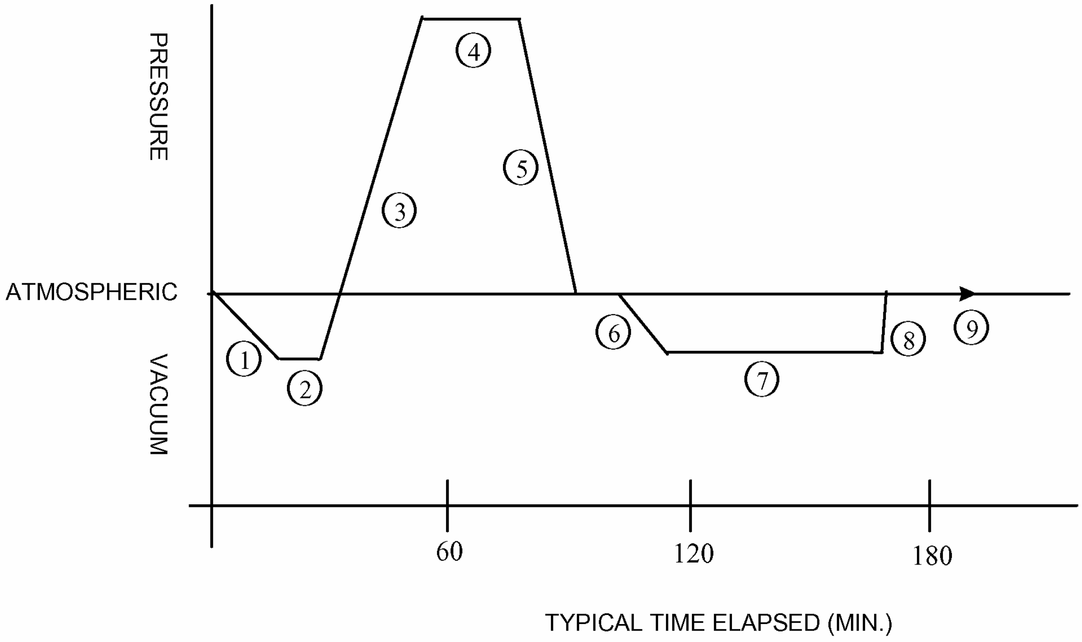
Sawn wood, which generally exposes refractory heartwood, requires "incising" to enable good preservative penetration. Incising is a process whereby the wood surfaces are punctured by toothed rollers. Various incising patterns are available to ensure good penetration without causing undue structural damage. Individual pieces are generally cut to final size and shape prior to treating to ensure good preservation of all exposed faces. Machining after treatment may expose untreated wood, in which case subsequent field treatments must be applied. Even properly applied field preservation cannot protect such exposed wood as effectively as either pressure or thermal treatments.

Full-Cell (Bethell) Process

The full-cell process was introduced in 1838. It is the only process employed for all treatments with CCA, and the other waterborne preservatives, as well as for creosote, where high preservative retentions are specified, as is the case with marine structures (Figure 1).

After a wood charge is placed into the pressure cylinder, the treatment process commences with the application of an initial vacuum for half an hour to an hour. The preservative solution is then admitted to the cylinder, while maintaining the vacuum. In case of the water-borne

Figure 1 The Full-Cell (Bethell) Pressure Treatment Process



Process Steps:

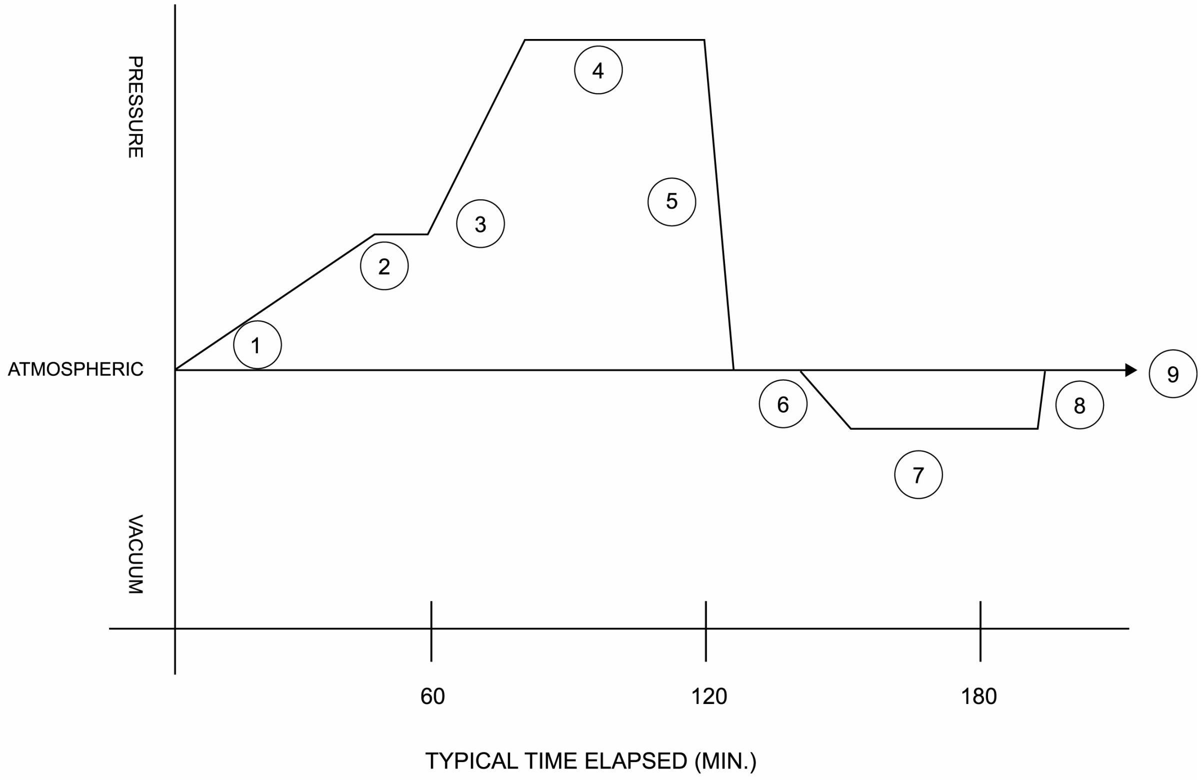
1 Initial vacuum
2 Fill with preservative
3 Pressure increase
4 Pressure impregnation cycle
5 Pressure release
6 Preservative pump-out
7 Final vacuum
8 Vacuum release
9 Treated wood discharge

preservatives, the solution is at ambient temperature, whereas oil-borne preservatives are heated (70 to 90°C). After the cylinder is filled, pressure is applied, usually to a maximum of 1040 kPa, and held until a predetermined amount of preservative has been injected into the wood. This pressure cycle may take from 30 minutes to several hours. At that point the pressure is released and the excess preservative is returned to a storage tank for use on subsequent treatments. The impregnation stage is usually followed by a final vacuum in the case of CCA and the other water-borne preservatives or an expansion bath and a final vacuum in the case of creosote. These processes remove excess preservative from wood subsurfaces and are aimed at rendering the product surfaces as dry as possible.

Empty-Cell Processes

This category includes two processes, the Rueping and the Lowry, both of which are used with creosote and pentachlorophenol for treatment of utility poles, railway ties, posts and construction lumber and timber. The processes are designed to give deep penetration, while minimizing the preservative retention (Figure 2).

Figure 2 The Empty-Cell (Rüping) Pressure Impregnating Process



Process Steps:
1 Initial pressure
2 Fill with preservative
3 Pressure increase
4 Pressure impregnation cycle
5 Pressure release
6 Preservative pump-out
7 Final vacuuum
8 Vacuum release
9 Treated wood discharge

The Rueping process applies an initial air pressure (200-500 kPa for 15 minutes) to the wood charge in the cylinder prior to admitting the preservative. The pressure compresses the air inside the wood. Hot preservative is then admitted to the wood, without releasing the air pressure. The pressure is increased to a typical maximum of 1040 kPa and held until a predetermined solution absorption has been achieved. When the pressure is released at the completion of the impregnation cycle, the compressed air in the wood expands and expels excess preservative. This effect, which is called the “kickback,” is usually enhanced by a quick final vacuum. Excess preservative is returned to storage for use in subsequent treatments.

The Lowry process is similar to the Rueping process, except that no initial air is applied and the preservative is admitted at atmospheric pressure. The remainder of the process continues in the same manner as the Rueping process. There is usually a smaller amount of preservative recovered by the kickback in a Lowry process.

Thermal Treatment Process

This process is applied with PCP/oil solutions for the full-length treatment of dry utility poles and cross-arms of thin-sapwood species (11). A pressure vessel is not required to carry out the process. Instead, most thermal treatments are carried out in horizontal, rectangular tanks that are covered by lids. During the cycle, dry wood is first immersed in hot preservative (88 to 113°C) for a minimum of six hours (hot bath). Thereafter, the hot preservative is quickly replaced by preservative at ambient temperature, in which the wood is held for at least two hours (cold bath). Excess preservative is returned to the storage tank.

A variation of this process is the “pole butt” treatment, whereby only the lower ends of poles (butts) are impregnated with preservative. This process is carried out in upright, cylindrical tanks and employs process parameters similar to the full-length treatments described above.

After-Impregnation Processes

After application of the pressure cycle, process steps are generally added to remove excess preservative from the wood, so as to render wood surfaces clean and dry or to fix the preservative chemically to the wood. Such processes are now quite common and are aimed at easing potential environmental and human exposures to preservative chemicals.

Most treatment cycles are followed by a final vacuum, which equilibrates internal pressure, removes air and preservative from the surface fibres of wood and, in the case of oil-borne treatments that use elevated temperatures, cools the wood. For creosote and PCP, a final vacuum may not be adequate to create clean surfaces. In these cases, the impregnation cycle may be followed by an expansion bath or a final steam cycle, both of which add a final vacuum step. These processes can be quite effective, but the final steam cycle creates large volumes of contaminated water that must be treated to meet all discharge criteria.

Storage After Treatment

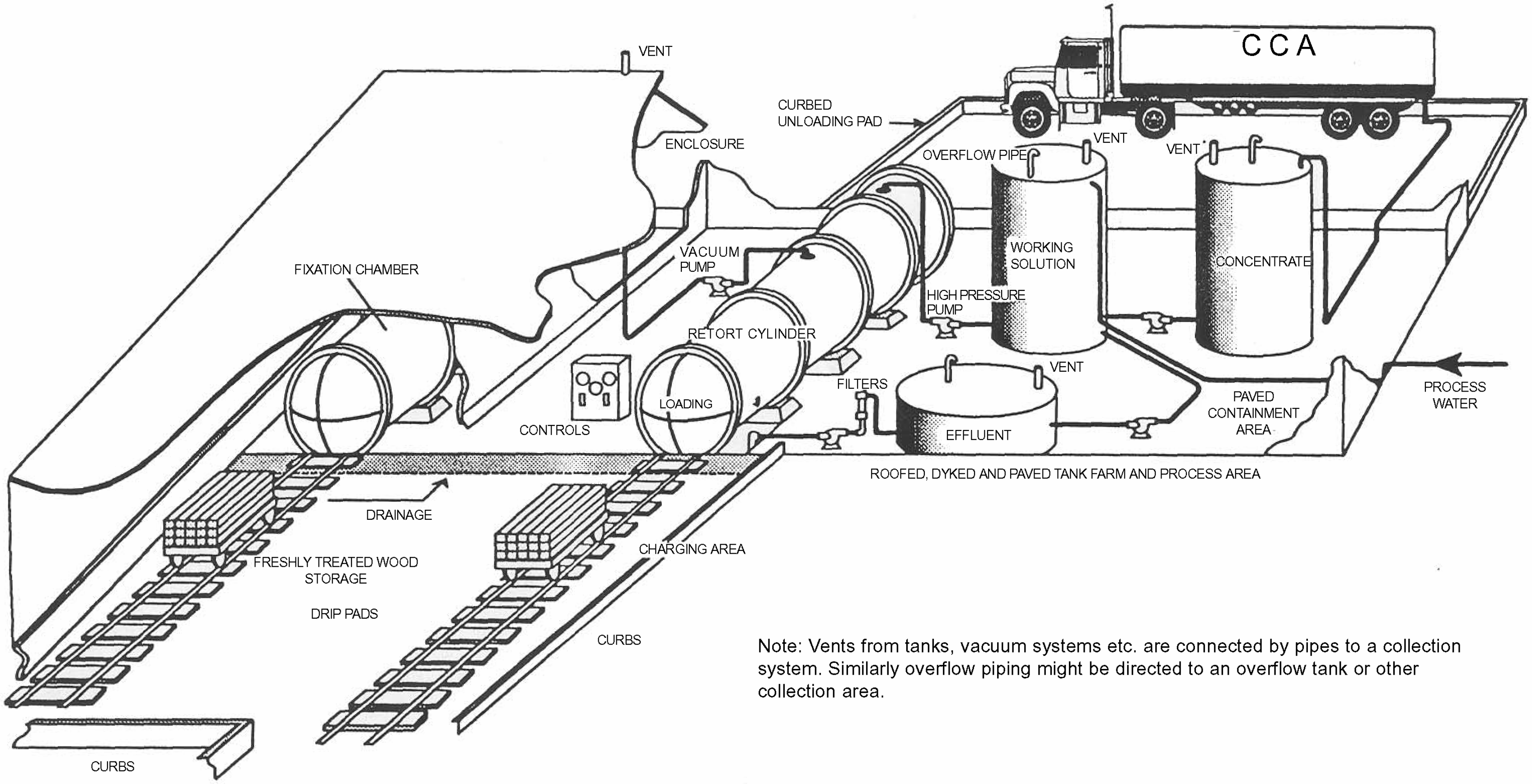
Treated wood, removed from the cylinder, is generally stored on a drip pad until preservative drippage has stopped. The duration of this storage may vary from hours to days. Alternatively, many CCA treatment plants now carry out an accelerated fixation process to ensure a high level of leach resistance of the preservative chemicals. Such a process entails a heating cycle, usually in the presence of high humidity. Special fixation chambers may be employed or the process may be carried out in drying kilns (13). From the drip pad of the fixation facility, the wood may be transferred to a designated yard area for storage until shipment or may be directly loaded onto railcars or trucks for immediate shipment.

2.2.3 Current Treatment Plant Designs

CCA Plant Designs

Most CCA plants are housed within a heated building (9). Figure 3 is a schematic view of a typical CCA plant. The centrepiece is the pressure vessel, also called a retort or cylinder. Cylinders are commonly 1.8 m in diameter and 24.4 m long. They are normally charged and discharged through a single door by means of trams that run on tracks. Other designs use conveyors to move wood in and out of the cylinder and may involve doors at either end to enter and exit the wood. Pumps are provided to apply process conditions (i.e. vacuum or pressure) as well as to transfer liquids from and to the cylinder and between tanks. A tank farm typically includes a concentrate tank, one or more tanks for working solutions, and an effluent recovery tank or makeup water tank. The process controls and instrumentation vary in sophistication, depending on the degree of automation. Most CCA plants have systems that are fully automated to control the impregnation process parameters. A number of plants have recently added heated storage areas for treated wood or special facilities for accelerating the fixation of the preservative components in the treated wood (13, 14). Paved drip areas for treated wood were enlarged in many plants, and some have roofs over some or all of the treated wood storage area.

During 2003 a significant number of CCA plants converted to application of either ACQ or CA-B. The general plant components involved with CCA apply to these chemicals as well, although additional tankage and heating equipment might be installed and the accelerated fixation facilities for CCA do not apply.



Note: Vents from tanks, vacuum systems etc. are connected by pipes to a collection system. Similarly overflow piping might be directed to an overflow tank or other collection area.

Figure 3 Conceptual Drawing of a CCA Treatment Facility

Similarly, borates can be applied in facilities that use the basic CCA layout. A roofed area is required for storage of treated material prior to wrapping, which is essential, because borates are water soluble and would leach when exposed to precipitation.

ACZA Plant Design

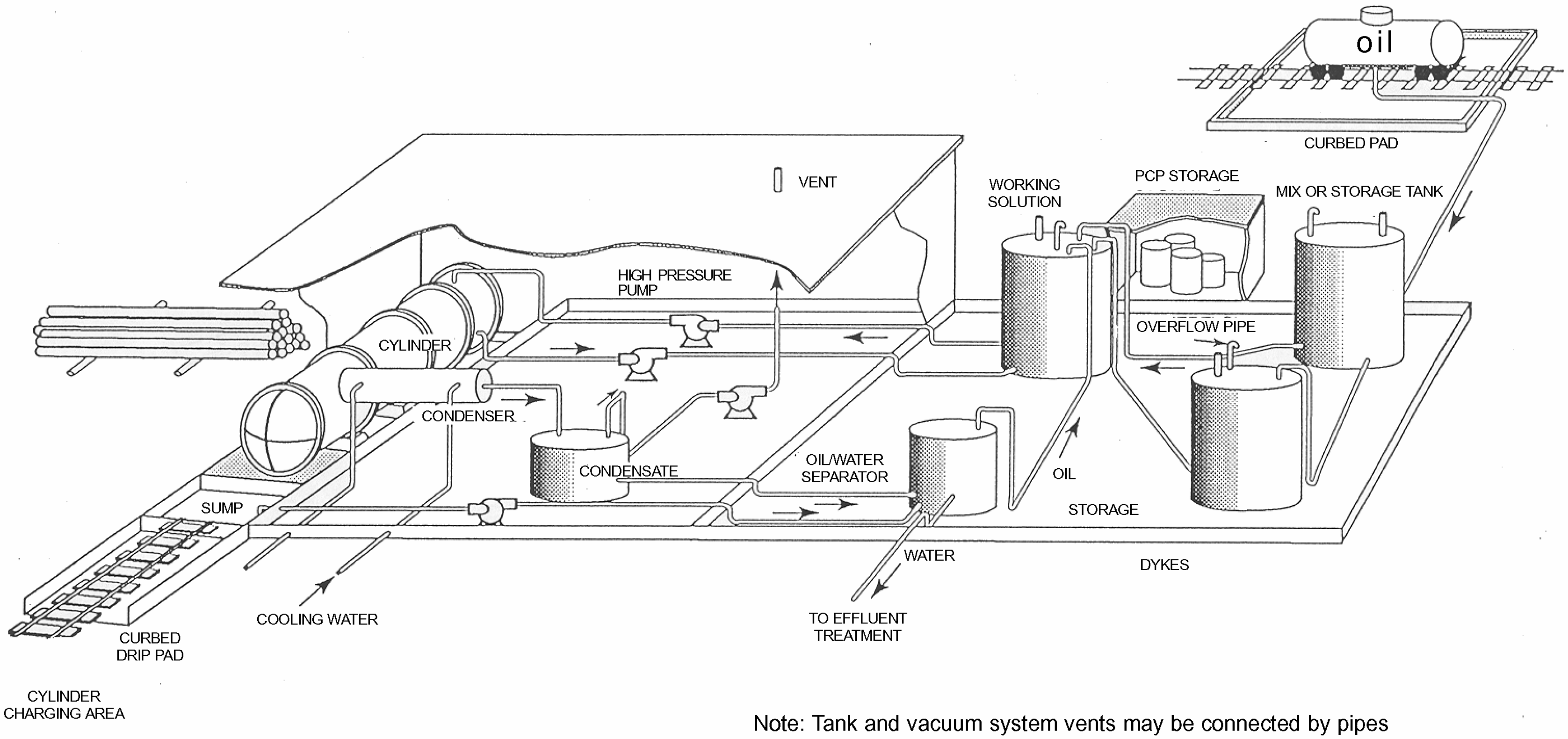
There is only one ACZA plant operating in Canada. This plant is enclosed and automated. The equipment is similar to that in CCA plants. Additional tankage is required for storage of the aqua ammonia and for mixing the ingredients to prepare a working solution.

Creosote and PCP Plant Designs

Creosote and PCP/oil solutions are often used interchangeably in the same treatment facility. Hence, plants using these preservatives have a similar layout (Figure 4). The pressure cylinders are usually somewhat larger than those used in water-borne preservation plants (2.1 m in diameter and 36.5 m in length). Tank farms are generally placed outdoors, and tanks are equipped with internal heating devices. The production equipment, including the cylinder, pumps, condensers, controls and effluent treatment systems, is within a treating house. Facilities treating with PCP or creosote solutions require a heat source for warming the preservative and to carry out specific processes, such as steam conditioning. When treating with PCP, either an autoclave or a designated mix tank is used to dissolve the solid preservative in a suitable oil solvent. Effluent treatment facilities may consist of an oil/water separator, a flocculation system and carbon filtration. An air filtration system to collect exhausts from treatment vessels, vacuum systems and tank vents may also be part of the installations. The vacuum systems are equipped with condensers and condensate collection tanks.

Thermal Treatment Plant Designs

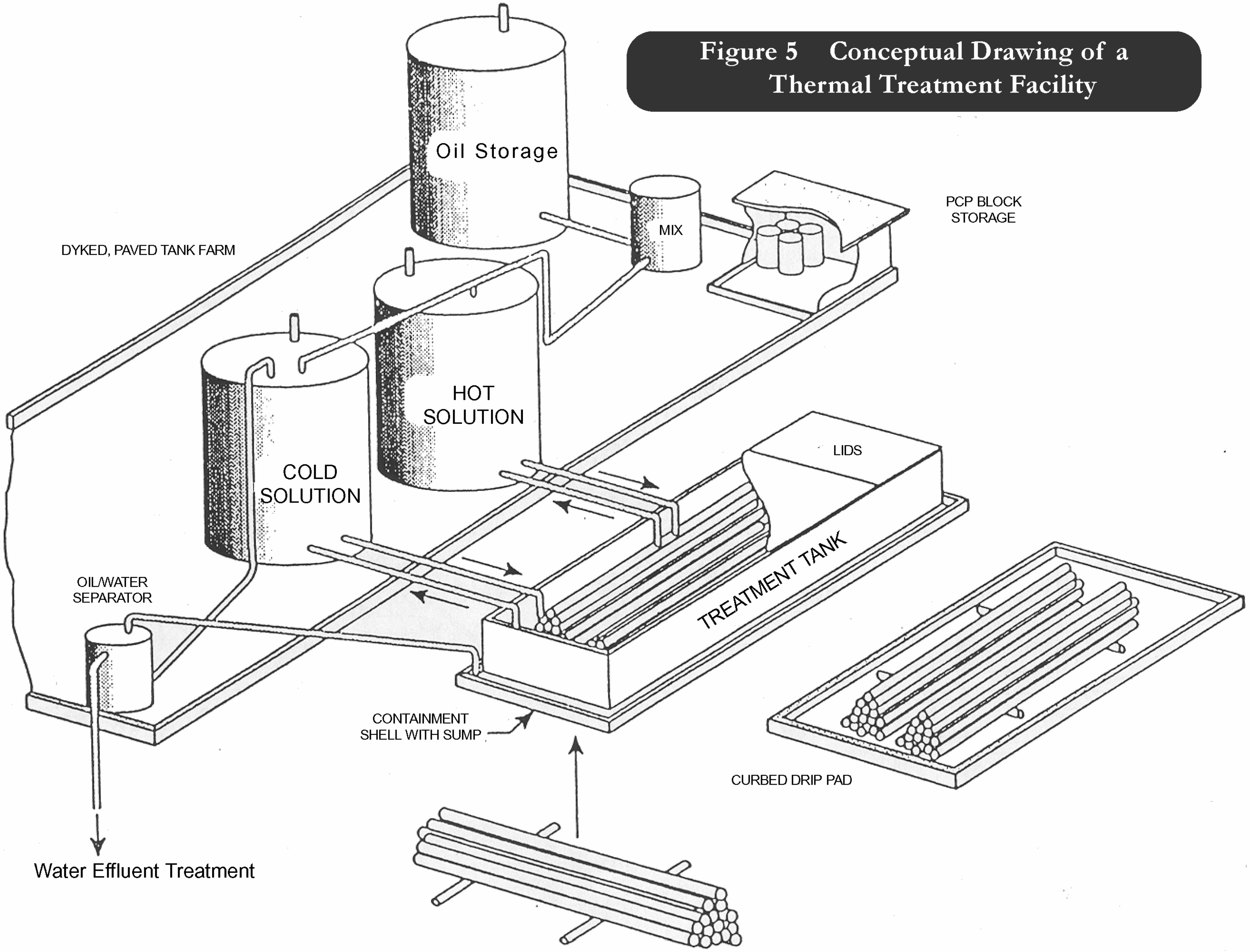
As Figure 5 shows, thermal plant facilities have less sophisticated impregnation equipment and process controls than pressure treatment facilities. The treatment vessel is a rectangular tank, which may be provided with spill containment. A tank typically measures 3.65 m x 3.00 m x 24.00 m and may be equipped with removable lids and hold-down bars for restraining the poles during treatment. Wood is loaded into the tanks by forklifts or grapples. An outdoor tank farm would contain a PCP/oil mix tank, as well as oil storage and hot and cold preservative solution storage tanks. Transfer pumps accomplish the removal of solution from the treatment vessel to the storage tanks. As with PCP pressure treatment facilities, the effluent treatment system may involve oil/water separation, flocculation and carbon filtration. One plant applies thermal treatments in a closed cylinder.



Note: Tank and vacuum system vents may be connected by pipes to a recycling or filtration system.

Figure 4 Conceptual Drawing of an Oil-Borne Pressure Treatment Facility (Creosote or PCP/Oil)

Figure 5 Conceptual Drawing of a Thermal Treatment Facility



3 Description of Preservative Properties

The commercial preservatives used in Canada have a long history of success in preserving a large variety of wood products. Not only are they effective in preventing wood deterioration, but each preservative also has physical and chemical properties that make it suitable for one or another product. No one preservative is considered suitable for all possible product applications; each has found a niche of preferential use.

The preservatives in use have a range of physical, chemical and toxicological characteristics that determine their potential for causing harm and, therefore, the best modes of handling them during operation. Their specific properties are described in Part II - Preservative-specific Information and Recommendations.

3.1 Toxicity, Hazards and Risks

The following explanations should allow a better understanding of the potential risks to humans and the environment (15):

Toxicity: any harmful effect of a chemical on an organism, including humans, or the environment. Exposure to wood preservatives can be in three basic forms: as pure active ingredients, as formulations, or as the treated wood. Toxicity can be short-term (acute toxicity), as defined by criteria such as the median lethal dose (LD_{50}) or the medium lethal concentration (LC_{50}), or long-term (chronic toxicity) that may have several effects, including cancer.

Hazard: the set of inherent properties of a chemical substance or mixture that makes it capable of causing adverse effects on humans or the environment, when a certain degree of exposure occurs.

Risk: the predicted or actual frequency of occurrence of an adverse effect of a chemical or a mixture from a given exposure to humans or the environment.

In most wood preservatives, the active ingredients are combined with other substances, most commonly solvents. Such preservative formulations may exhibit different physical and toxicological properties from the undiluted preservative. This factor needs to be taken into account when recommendations for proper designs and operational practices are proposed.

3.2 Human Health Concerns

Wood preservatives can be harmful to humans, if not properly handled. The exposure routes by which they can enter the human body are inhalation (vapour, dust, aerosol, etc.), ingestion (solid, liquid) and through the skin (vapour, liquid, solid). Exposure limits are given for individual preservatives in Part II - Preservative-specific Information and Recommendations. Such limits are usually also contained in the material safety data sheets issued by chemical manufacturers.

Plant operators should obtain references to or copies of relevant material safety data sheets (MSDS) from their preservative supplier and follow the requirements of the pesticide label.

3.3 Environmental Concerns

The properties of a preservative chemical or formulation are also important in determining its environmental fate and its potential for contaminating the treatment plant and other sites. A preservative can enter the environment in many ways, such as by spillage or leaching, as effluent or air emission. Subsequently it may be subject to a wide variety of processes that may eliminate it from the environment completely, modify it into a more or less harmful substance, or transfer it to another environmental medium (15).

The main physico-chemical properties that determine the migration of a chemical are (15):

- solubility in water and in organic solvents;
- vapour pressure;
- adsorption/desorption in soil or sediment;
- stability;
- partition coefficient between octanol and water;
- reactivity with co-contaminants and soil microbes.

Detailed information on the environmental considerations for each preservative is contained in Part II - Preservative-specific Information and Recommendations.

4 Description of Preservative Applications and Potential Chemical Discharges

The use of wood preservatives at treatment plants creates the potential for human exposure and may lead to chemical discharges to the environment. The actual impact of any chemical depends upon many factors, including the site, facility characteristics, processes employed and operational practices. Due to their physical, chemical and toxicological properties, as well as their modes of application, each type of preservation facility requires specific attention to ensure safe operation.

See Part II - Preservative-specific Information and Recommendations.

5 Personnel Protection

5.1 Precautions and Hygiene

The potential hazards of exposure to preservative solids or their solutions include immediate and long-term toxic effects from ingestion, skin contact or inhalation of vapours or other airborne contaminants. These potential hazards can be adequately controlled by proper protective measures. The severity and speed of damage to tissue and probability of health effects following contact depend on the extent of the exposure and are generally highest with concentrated solutions. These factors diminish as the solution is diluted. The general rule for dealing with exposure is as follows: **the higher the concentration of a preservative to which a worker is exposed, the greater the need for protective measures and immediate response if contact occurs**. If there is any doubt as to the concentration, the response should be the same as for the most concentrated form.

The first aid procedures for exposures to specific preservatives and objectives for an overall worker protection program are contained in Part II - Preservative-specific Information and Recommendations.

First aid personnel must be properly trained and should maintain regular contact with chemical suppliers and/or industrial medical advisors for information on up-to-date response measures. Table 1 outlines general precautions and personal hygiene measures for an overall worker protection program.

5.2 Regulatory Controls

Most regulatory criteria established by worker protection agencies are based on threshold limit values (TLVs) and biological exposure indices, as recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). Part II - Preservative-specific Information and Recommendations presents the ACGIH-recommended limits for individual preservatives to define acceptable levels of exposure in the wood preservation workplace.

The hygiene and protective measures as well as precautions recommended in this document represent general good practice to ensure minimal worker exposure. However, such measures to protect workers may differ from various federal and provincial regulations. For example, under the federal *Pest Control Products Act* all pesticides including all wood preservatives are required to be registered and to carry a label issued by Health Canada. The pesticide label contains specific requirements for handling and use of the preservative as well as the protective measures that apply. The user must be familiar with these and must comply with them.

5.3 Biological Monitoring of Exposed Workers

Biological monitoring is a useful tool for evaluating the long-term effectiveness of the protective measures applied. Routine biological monitoring of exposed workers (primarily those who handle preservatives and treated wood, e.g. plant operators and quality control personnel) is recommended and can be achieved using established procedures for determining the presence of the various preservatives and their components. Among these procedures are analyses of urine, blood or hair. Note that biological monitoring might not be possible for all preservative ingredients and solvents used. The monitoring programs should be carried out and interpreted by qualified occupational hygienists or occupational physicians. If there is concern for confidentiality and/or sample handling procedures, these can be addressed and resolved by a joint management-worker committee.

A comprehensive occupational health and safety program is important for worker health and safety. Two components of such a program are environmental and worker health monitoring, which may be used to assess worker exposure to wood preservatives. Since occupational health and safety is under provincial jurisdiction, the appropriate workers' compensation board or department of labour should be contacted for specific requirements for wood preservation facilities.

Table 1 General Precautions and Personal Hygiene for Personnel Working in Wood Preservation Facilities

General Precautions	
Objective	**Recommendations**
Assure that workers are familiar with all aspects of preservative usage.	• Provide documentation and training to educate workers about the chemical properties of, hazards of exposure to, and emergency procedures associated with use of the preservative. • Implement preventive measures to minimize ingestion or inhalation of, and skin or eye contact with, preservatives, preservative solutions and contaminated waters.
Assure that first aid can be applied when necessary.	• Install and regularly check emergency eyewashes and showers. • Provide all necessary first aid equipment for first response as indicated in Part II of this document. • Ensure that first aid is always available from qualified (trained) personnel. • Ensure first aid personnel are familiar with updated emergency response procedures. • Identify medical contacts who are readily available during all working hours.
Personal hygiene	
Implement personal hygiene practices that minimize potential exposure to preservatives.	• Do not carry, store or consume food or drink in working areas (e.g. areas where preservatives are stored or used, or where freshly treated wood is stored). • Do not carry or smoke cigarettes in working areas. • Wash hands thoroughly before leaving working areas and before eating, drinking, smoking or using the toilet facilities. • Do not expose cuts or abrasions to preservatives. • Wash skin immediately if contact with preservative solutions occurs. • Get immediate first aid if skin or eyes contact preservative solutions. Even small contact exposures should receive immediate cleaning and treatment. • Change outer clothing immediately if splashed with preservative solutions. Change clothing daily if any incidental contact with the treatment chemical occurs. Wash contaminated clothing separately from other clothing. • Wear impermeable footwear in all working areas. Preservative solutions may penetrate leather shoes and apparel. • Shower daily immediately after work. • All work clothing and boots must be left at the plant.

6 Site Selection

6.1 Purpose

Preliminary assessment of an industrial site involves an evaluation of technical site characteristics (e.g. hydrogeology, topography and soils) and of socio-economic and geographic factors (e.g. cost, land use and availability, proximity to raw materials, markets and transportation routes). This section highlights site features that contribute to the control of any potential chemical releases from wood preservation facilities.

In many cases, natural site characteristics may impose constraints on the technical features of a facility. Early recognition of less desirable characteristics will allow development of a compensating design and speed site approval.

6.2 Assessment Factors

Active plant sites have the potential for chemical contamination of groundwater and surface water. The extent of potential contamination is dependent on the type of chemical, its physical and biological properties, plant design and operating practices, and site-specific characteristics including soil type, geology, hydrology (subsurface), climate, topography and drainage.

This section describes environmentally important site characteristics and how those characteristics can affect the eventual impact of a chemical release. These characteristics are important in designing features of a wood preservation plant that:

a) minimize the possibility of off-site contamination via groundwater and surface water;
b) minimize chronic on-site contamination to protect worker health during operation;
c) facilitate decommissioning in the event of partial or complete closure.

The preliminary assessment factors rely on readily available information. Table 2 lists the site features that must be considered in an environmental impact assessment.

6.2.1 Regional Geology

Geologic information about many areas of Canada may be obtained from federal and provincial surveys. Information that should be obtained includes:

- Texture of unconsolidated material — Fine-grained material is more likely to retain chemical contaminants than coarse material.
- Depth to bedrock — Shallow soils imply a limited ability to retain spilled chemicals.
- Aquifer recharge and discharge zones — Potential for hydraulic connections to regional groundwater and sensitive surface waterbodies should be considered.
- Discontinuities such as faults, fissures, joints, fractures — Discontinuities may cause “short-circuiting” of a contaminant plume.

Table 2 Site Features Affecting the Design of a Wood Preservation Facility

Site features	Suggested degree of mitigating design/operational measures: Slight	Severe
Soil texture	Loam, silty loam, silty clay loam, clay loam, sandy clay	Gravel
Permeability (cm/h)	< 0.5	> 50
Topography (% slope)	0 - 9	> 30
Soil depth to bedrock (cm)	> 200	< 60
Depth to groundwater (cm)	>200	< 60
Flooding	None	Frequent (>once/20 years)
Drainage	Slow	Very rapid
Distance to surface waterbody (lake or river)	Depends on interaction with other site features (e.g. permeability of soil)	Directly adjacent

6.2.2 Soils

Soil properties should be assessed to evaluate the potential for leaching of treatment chemical constituents. Physical properties to consider include depth, permeability, texture, water-holding capacity and shrink-swell potential; chemical properties to consider include cation exchange capacity (CEC), anion exchange capacity (AEC), organic carbon content, and iron and aluminum oxide content. Soils with high amounts of organic carbon will have higher capacities for sorption of neutral organic compounds; those with high AEC will provide greater retention of dissociated phenols; while those with high CEC will provide greater retention of organic bases. High AEC, high levels of aluminum oxides, and/or high levels of calcium compounds will enhance the retention of arsenate and chromate anions, while high CEC, high clay content and high organic matter will enhance the retention of the copper cation.

Soil depth and soil types are routinely indicated on soil maps (and often on geology maps). Although the available maps may not indicate the exact soil composition of a small site (e.g. 2 ha), they can be used for preliminary assessment purposes.

6.2.3 Geotechnical Description (including subsurface hydrology and water table data)

Published maps and reports on regional geology and soils are adequate references for establishing subsurface hydrogeology at the preliminary site assessment stage. However, site-specific hydrologic data will be required if one or more of the following conditions are identified during preconstruction assessment:

- the site is located over a shallow, unconfined aquifer;
- the site is located over an aquifer used for a potable or irrigation water supply;
- the aquifer has hydrologic connections with other aquifers in the area and/or regional groundwater flow patterns.

The additional information required must be defined in consultation with the appropriate regulatory agency.

6.2.4 Topography

Topographical information is easily obtained from published government maps. In general, steep sites should be avoided due to runoff problems and erosion. However, topography is a site selection parameter that can be addressed by facility design. Slope gradients between 1% and 10% should present few problems. Upland flat and terraced landforms are desirable locations for treatment facilities. Floodplains are acceptable if they lie above the 100-year flood level; otherwise special design provisions must be implemented.

6.2.5 Climate

Climactic variables, such as precipitation (form, historical 1-hour and 24-hour maximums, and annual total amount), temperature regime and wind patterns, influence chemical loss during storage of treated wood and leaching in the subsurface. Climactic variables can also influence conditioning needs for wood prior to preservation treatment and can affect worker exposure to emissions. Information on such climactic variables is generally available from Environment Canada. However, definitive criteria are difficult to establish for climactic influences. For example, the amount of precipitation will influence leaching potential, but this parameter can be alleviated by selecting sites with soils of low permeability and/or by introducing compensating design features at the facility.

6.2.6 Proximity to Sensitive Uses

Sites located adjacent to waterbodies (e.g. lakes, rivers, marine waters) or above aquifers used for drinking or irrigation water supplies, food manufacturing plants and beverage processing plants should be considered cautiously by the wood preservation industry. If such a site is selected, exceptional design approaches and operational and monitoring procedures will be required. Desirable minimum distances between facilities and sensitive waterbodies depend upon previously discussed factors such as soil type, regional geology, topography and climate. If a selected site is adjacent to waterbodies used by migratory fish, then the plans must be reviewed by both Environment Canada and Fisheries and Oceans Canada.

6.3 Selection Procedures

After compiling the data for potential sites, the developer is faced with a decision-making process for site selection. The process integrates environmental protection with economic considerations. On the basis of economic factors alone, a less environmentally acceptable site might be most desirable. However, since the less acceptable environmental features will add to the cost of adapting the design and operation of the plant to the site, environmental protection must be interpreted as a real location cost at such a site.

All factors previously described should be considered. Techniques used to select a site on the basis of environmental acceptability include criteria ranking, matrices, decision trees or mathematical modelling. Since assessment techniques among regulatory agencies may vary considerably, local and provincial regulatory agencies (and federal agencies where necessary) must be consulted.

Table 2 provides examples of site characteristics requiring very little environmental mitigation as well as those requiring significant mitigation. Deviations from the most desirable characteristics suggest various degrees of mitigating design and operational measures:

- Slight mitigating design/operational measures are necessary for sites that are well suited to the location of a treatment facility. The site will require only low-cost maintenance and monitoring to assure environmental protection.
- Moderate mitigating design/operational measures present more of a problem, but in general sites requiring such measures are acceptable.
- Severe mitigating design/operational measures such as special innovative designs may partially overcome the constraints of a marginally suitable site. Design costs are likely to be high. Extensive monitoring efforts will be required, adding to the cost of the location.
- Very severe mitigating/operational measures indicate that a site may be economically impractical and should not be considered.

Site features and the degrees of mitigating design/operational measures shown in Table 2 are based on siting criteria suggested by various investigators (16, 17).

7 Design Recommendations

This section suggests approaches to designing wood preservation facilities that protect workers and the environment from harmful exposure to preservative chemicals. Recommendations are based on currently available best practices. The design aspects are intended to achieve the following general objectives:

- to prevent or reduce direct contact of personnel with preservative chemicals;
- to provide maximum reduction of preservative releases to the environment by providing secure containment;
- to enable prompt response and effective corrective measures to assure worker safety and environmental protection after abnormal events (e.g. tank rupture).

Figure 6 presents an overview of the subject areas covered by the design objectives. It is based on the typical handling and use of preservatives. Means of achieving the objectives outlined in Figure 6 are presented in Tables 3 to 9.

It is intended that all new wood preservation facilities be designed to achieve the specific objectives listed in these tables. Existing facilities should review their abilities to comply with the objectives, and gaps, if present, should be addressed using the suggested features or alternative but similarly effective features. Assessment 2000 aided plants in the determination of shortcomings in design and operation, and through the Strategic Options Process for the industry, plants have pledged to meet the objectives of the TRD by the end of 2005.

The recommended design features in the tables may not be the sole options available to attain the stated objectives. Alternative approaches may exist that would be equally effective or more suitable to site-specific conditions. Where this is the case, an appropriate design feature that has not been included in these recommendations could be used at a specific facility.

Note that roofing is a recommendation for several process areas. But galvanized roofing may contribute to stormwater runoff toxicity from mobilized zinc. Particular caution with such roofs should be exercised at sites near waterbodies or in areas of low pH precipitation.

Figure 6 Overview of Design Recommendations for Preservation Facilities

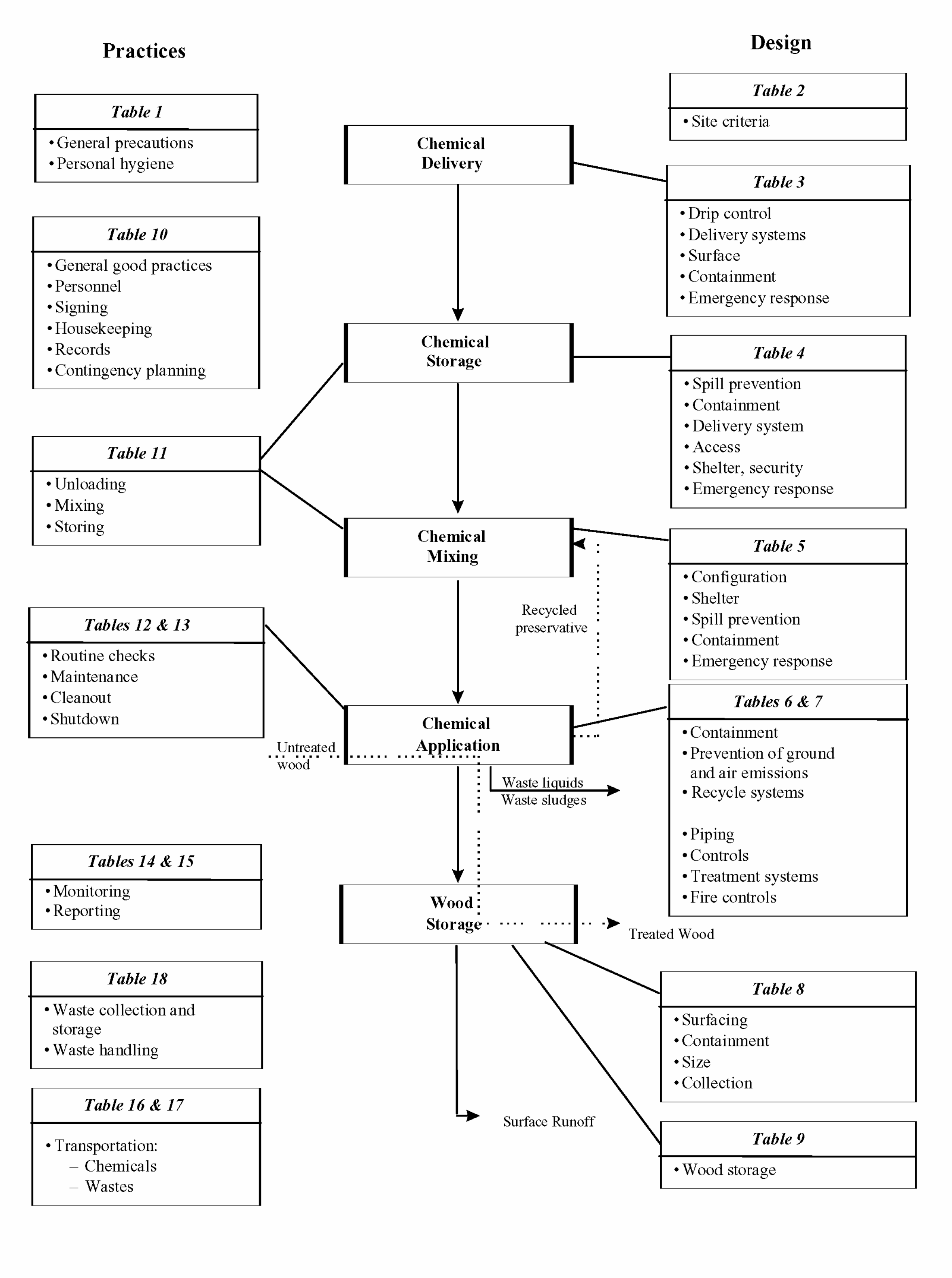


Table 3 Recommended Design Features for Chemical Delivery Areas

Delivery format	Design feature	Recommendations
Bulk liquid (delivered by truck or rail tanker)	**Objective:** To provide an off-loading area that enhances spill prevention and containment.	
	Off-loading pad	• Provide an impervious pad that drains to a containment area. • Design to prevent settling or cracking of the pad.
	Surfaces	• Seal surfaces to prevent leakage and enhance cleanability.
	Joints	• Provide liquid-tight joints (if applicable).
	Drip control	• Provide local drip catchment to minimize contamination of the containment system. • Provide for wash down of minor drips or spills with recovery of washwater (or infiltrating precipitation) for reuse.
	Access	• Locate off-loading area away from high yard traffic routes. • Restrict access during delivery.
	Delivery system piping	• Install permanent delivery systems with rigid, accessible, visible delivery lines (not buried). Piping in sealed, contained channels with leak detection is an optional approach. • Protect delivery systems from mechanical damage. • Provide mechanically secure connections between the tanker and delivery hook-up point. • Clearly identify all delivery lines. • Use top delivery to concentrate storage tanks.
	Backflow prevention	• Install backflow preventers on delivery line.
	Security	• Install locking valves on delivery lines; restrict access.
	Overflow prevention	• Provide maximum visibility of the delivery system from the point of off-loading. • If visibility is limited, use audible alarms to detect tank overflow during delivery.
	Emergency response	• Provide accessible storage for spill-response equipment, absorbent and personnel protection equipment. • Install a phone or manual alarm switch near the off-loading area.
Containerized liquid (drums)	**Objective:** To provide an off-loading area that enhances spill prevention and containment.	
	Off-loading pad/shelter	• Provide an off-loading area near the storage area
	Containment	• Ensure containment for a worst event spill (e.g. 4 drums or 1 pallet load).
	Surfaces	• Provide a sealed surface.
	Container handling	• Design for safe manipulation of containers.
	Emergency response	• As for bulk off-loading areas.

Table 4 Recommended Design Features for Chemical Storage Areas

Storage format	Design feature	Recommendations
Bulk liquids • Solvents • Concentrates • Working solutions • Contaminated surface runoff • Drip return	**Objectives:**	◊ To provide positive spill prevention features. ◊ To provide spill containment capability of 110% of the volume for a single tank, and in multiple tank containment to provide 100% of the largest tank plus 10% of the aggregate volume of the remaining tanks or 110% of the volume of the largest tank, whichever is greater (18).
	Tanks	• Engineer construction materials and dimensions in consultation with chemical suppliers and applicable codes. • Provide tanks in sound physical condition, with no rust or serious physical damage. • Mount tanks on containment pad surfaces. • Mount tanks in stable positions and anchor securely. • Locate tanks within a dyked area. • Shelter from the weather (where appropriate) and protect from mechanical impact, vandalism. • Protect against freezing (as recommended for external tanks). • Provide means for detecting leaks in insulated tanks (e.g. identify inspection points, undertake regular leakage tests). • Vent interior tanks to the exterior or into a dedicated overflow tank (**never** vent directly into the workplace): – protect vents against release of entrained liquids or overflow (e.g. direct overflow piping to sumps or containment areas).
	Spill containment	• Install impervious, structurally sound floors. • Provide structurally sound dykes, seal all joints. • Provide a dyked containment volume (as stated under the objectives above). • Engineer containment for long-term integrity (leak-proof for infiltration and exfiltration). • Provide either an impermeable top coat to floors and dykes or a liner under the containment area. • Consider providing means for detecting subsurface leakage from containment systems (where warranted by site-specific conditions; e.g. where the site overlays sensitive groundwater systems). • Provide for directing all spills, washes and infiltrating water to tankage (contaminated liquids must be treated to applicable limit before discharge). • Provide effective capability for transferring spilled liquids from containment areas. • Provide surface drainage to prevent pooling of minor spills and washdowns. • Design to minimize tracking of fluids from containment surfaces.

Table 4 Recommended Design Features for Chemical Storage Areas (continued)

Storage format	Design feature	Recommendations
Bulk liquids (continued)	**Piping and valves**	• Design according to applicable codes. • Use rigid, permanent piping throughout. Tank car/truck unloading requires shielded and protected hose connection. • Provide visible, accessible piping with a simple layout (to facilitate early leak detection and easy repair). • Maximize above-floor piping or open containment channels for subgrade piping. **Do not bury** piping! • Properly engineer piping systems for material and dimensions. • Identify piping systems and valves (e.g. by labelling and/or colour coding). • Provide mechanical impact protection for vulnerable exposed piping. • Provide freezing protection for piping (as required).
	Drip containment	• Provide local collection/containment (isolated from large containment areas) at drip points (e.g. under pumps, valves, flanges, etc.).
	Spill prevention / detection	• Install reliable, accurate level indicators on all tanks. • Provide mechanical impact protection on glass sight gauges (including provision for containing and stopping release from broken gauge tubes). • Install shut-off valves on all rupturable lines and tank gauges. • Install permanent overflow piping from tanks directly to a definitive contained area. • Install reliable, independent high-level alarms on tanks (visual and audible alarm). • Interlock high-level alarms to tank feed pump (auto shut-off). • Consider installation of 24-hour monitoring alarms (with remote) for immediate detection of major spills. • Install emergency communication means (e.g. telephone, manual alarm button) at potential major spill points.
	Backflow prevention	• Design to protect against inadvertent transfers to/from interconnected tanks.
	Shelter	• The preferred location for tanks containing aqueous liquids (all solutions) is in an interior centralized process area. • The preferred location for oil-type liquids is in an exterior centralized tank farm area. • If possible, roof exterior tank farms to minimize the quantity of infiltrating precipitation.
	Security	• Provide security precautions to prevent vandalism or access by unauthorized persons.

Table 4 Recommended Design Features for Chemical Storage Areas (continued)

Storage format	Design feature	Recommendations
Bulk liquids (continued)	**Emergency response**	• Provide accessible storage for spill response equipment, absorbents and personnel protection equipment. • Provide appropriate measures for fire detection and suppression, as well as for rapid, effective fire control with containment of liquid firefighting residues and treatment to required limits before discharge. • Install a telephone and manual alarm switch near the off-loading area.
Drummed liquids	**Objective:** To provide secure storage with containment for the worst event spill.	
	Location	• Provide safe, easy access to the mixing area.
	Shelter	• Provide storage in an enclosed, secure area, segregated from other chemicals.
	Ventilation	• Provide adequate ventilation for routine operations and emergency situations.
	Containment	• Store in a paved, curbed or dyked area with no floor drains: – provide containment capacity for the worst event spill (no less than 4 drums), – provide for effective cleanup (including recovery of washdown water) in the event of a spill.
	Surfaces	• Seal surfaces and joints to facilitate cleanability and surface impermeability.
	Emergency response	• Provide accessible storage for spill response equipment, absorbents and personnel protection equipment.

Table 5 Recommended Design Features for Chemical Mixing Systems

Chemical form	Design feature	Recommendations
Bulk concentrate	**Objective:** ◊ To provide a mixing system with effective spill prevention features. ◊ To provide a mixing system that minimizes worker contact with base ingredients and concentrates.	
	Configuration	• Use permanent, closed systems (rigidly piped, tank to tank).
	Location/shelter	• Locate in a contained area.
	Spill prevention	• Install high-level alarms to prevent mixing tank overflow. • Interlock high-level alarms to tank feed pumps.
	Spill containment	• Provide all applicable features for spill containment of bulk liquids described in Table 4.
	Drip containment	• Provide local drip collection at all potential drip points.
	Splash protection	• Discourage open transfer operations; if unavoidable, provide reliable splash protection.
	Emergency reponse	• Provide emergency response features described in Table 3.

Table 6 Recommended Design Features for Treatment Process Systems: General Recommendations

Design feature	Recommendations
Objectives: ◊ To minimize and contain all releases of preservative chemicals. ◊ To recover and recycle releases that occur.	
Spill containment	• Provide spill containment capability of 110% of the volume for a single tank, and in multiple tank containment provide 100% of the largest tank plus 10% of the aggregate volume of the remaining tanks or 110% of the largest tank, whichever is greater. • Locate treatment cylinders and process tanks in an area with: – continuous, structurally sound concrete floors or with slabs or sections with sealed joints, – sealed surfaces for cleanability and impermeability, – reinforced dyke walls and sealed joints, – graded surfaces for ready drainage of wetted surfaces, – walkway grates (or alternative design) to minimize worker exposure and prevent tracking of chemicals from containment areas — keep surfaces clean. • Provide either an impermeable top coat to floors and dykes or a liner under the containment area. • Engineer containment for long-term integrity (leak-proof for infiltration and exfiltration). • Provide permanent, isolated drainage/transfer systems to direct all spills, washes and infiltrating water to tankage. Treat contaminated liquids to applicable limits before discharge. • Isolate control and transfer equipment to avoid damage from spilled liquids in containment areas.
Process control area	• Segregate the operator control area from retort and tank spill containment areas. • Locate the process control area for maximum visibility of treatment systems. • Provide proper lighting in all operating areas.
Process emissions to air	• Provide control equipment for any air emissions vented to the interior, including tank and any emissions subject to environmental controls. – prevent worker exposure to vacuum pump exhausts, – install additional control equipment as required to comply with applicable air emissions limits, – provide traps to remove entrained liquids, – assess levels of workplace air contaminants. Provide ventilation in areas where excessive levels may occur, – where applicable, condense emissions and return to storage.
Fire control	• Provide fire controls as decided on site-specific basis in consultation with the local fire department. • Provide containment for contaminated runoff waters and residues generated by firefighting activities (e.g. blockage of storm drains, adjacent ditches).
Weather protection (winter operations)	• Protect equipment from freezing temperatures, particularly where water is or may be present. • Winterize process control area.

Table 7 Recommended Design Features for Treatment Process Systems

Design feature	Recommendations
Objectives: ◊ To provide fail-safe operation of the treatment system. ◊ To minimize the potential for preservative spills.	
Treating cylinder	• Treatment cylinder and pressurized components must meet all pressure vessel certifications stipulated by the provincial ministry responsible for such certification. • Install an effective protection device to prevent doors opening when the cylinder is pressurized or filled with preservative: – provide independent backup protection, – install independent indication and/or alarm/interlocks between the cylinder door and the control point (where the door is not visible from the control point). • Design to facilitate drainage of excess preservative.
Piping and recycle systems	• Design an overall system that is effective at containing and recycling all chemicals with minimum potential for release and dispersal and minimum infiltration of water. • Select and install piping as per Table 4.
Sumps	• Provide leakproof design (e.g. impermeable surfaces, sealed joints). • Provide a tertiary containment for sumps (e.g. steel lining or other suitable materials or devices) in addition to the concrete containment and impermeable liner or coating. • Provide overflow protection if sump is not in containment area (e.g. install independent high-level alarms).
Process controls	• Design for simple, unambiguous operation (regardless of the degree of automation). • Establish a clear relationship between process controls and process functions in order to minimize operator error.

Table 8 Recommended Design Features for Freshly Treated Wood Drip Areas

Design feature	Recommendations
Objectives: ◊ To minimize losses of preservative chemicals from treated wood to the environment by: - providing adequate controls to ensure minimization of preservative drippage prior to removal to unprotected storage areas, - controlling the generation and disposal of contaminated runoff waters.	
General design	• Consider integrated design provisions for: – shelter from precipitation, dust, debris, – efficient drip and runoff collection and containment, – surface drainage and return of fluids to process with minimum dispersal from tracking by personnel and vehicles.
Drip area	• Provide a sufficiently sized and contained area to hold all freshly treated wood until visible dripping ceases. • Roofing, as an alternative to collection and treatment of contaminated waters, might be necessary in areas of high precipitation.
Containment	• Provide impermeable and curbed charge unloading and drip areas, sloped to enable collection and storage of all runoff and infiltrating precipitation (for reuse or controlled discharge under terms of existing regulatory standards). • Provide drip areas with either an impermeable top coating on floors and dykes/berms or a liner underneath.

Table 9 Recommended Design Features for Treated Wood Storage Areas

Design feature	Recommendations
Objective:	To minimize and control releases of contaminated surface waters from treated wood storage areas.
Storage areas	• Where applicable, fix the preservative prior to yard storage. • Store treated wood under roof or wrap and provide impermeable flooring where continuing dripping or leaching may cause excessive runoff or ground contamination. • Elevate treated wood packages above the ground by placing them on supports to avoid treated wood contact with runoff water. • Maintain minimum inventories of treated wood. • Segregate treated wood storage areas from uncontaminated runoff water to minimize the need for water treatment and/or recycling. • Locate unsurfaced ground storage areas away from surface waterbodies. • Routinely monitor contaminant levels in storage area runoff. • Evaluate options for storage area surfaces on the basis of factors such as groundwater, usage, probability of bleeding/leaching and expected levels of precipitation (large paved areas will result in large quantities of runoff waters but may be necessary if groundwater is used for drinking water supply). As per the National Fire Code of Canada (19): • “yard storage areas shall be separated from mill operations and other structures by an acceptable clear space permanently available for fire-fighting operations.” • “storage site shall be maintained free of combustible ground vegetation including grass and weeds for at least 4.5 m from the stored material and at least 30 m from bush or forested area.” • “lumber treated with combustible liquids shall be stored in piles separated from other stored material, . . . not less than 4.5 m.” • “at least two fire department access routes shall be provided.”

8 Operational Recommendations

In addition to the design objectives described in section 7, a preservation facility must develop operating procedures to protect both workers and the environment from harmful exposure to preservative chemicals. The protective measures recommended in this document must be used in conjunction with those provided on the pesticide labels issued by the Pest Management Regulatory Agency (PMRA) under the *Pest Control Products Act*. The operating procedures should:

a) minimize direct contact of personnel with wood-preserving chemicals;
b) minimize releases of chemicals to the environment;
c) facilitate clear and accurate definition of responsibility and action when emergency response is required.

Recommended operating practices are presented in Tables 10 to 13 and include:

- general practices (Table 10);
- procedures for handling and storing chemicals (Table 11);
- practices for operating process systems (Table 12);
- practices for maintenance, cleanout and shutdown of preservation systems (Table 13).

The recommendations may not be the sole options available to attain the objectives. Alternative approaches may be equally effective or more suitable in view of site-specific conditions. When programs are developed for a particular facility, the specific recommendations may be modified if it can be demonstrated that an alternative approach, more suitable to plant-specific conditions, would be equally effective in attaining the objectives.

It is recommended that all existing and new wood preservation facilities meet the objectives outlined in Tables 10 to 13 by implementing the practices or their equivalents. Detailed operating procedures for each facility should be incorporated into a written operations manual available to all personnel. Responsibility and accountability for implementing procedures should be clearly assigned to supervisory personnel and to workers.

Table 10 Recommended General Practices for Operating Wood Preservation Facilities

Operation	Recommendations
Personnel	**Objective:** To enhance worker protection by providing education and medical surveillance.
	• Train all forepersons, on-scene supervisors, operators and handlers in good work practices. • Provide periodic review and update of education and training. • Provide pre-employment medical checkup and annual ongoing medical surveillance (see section 5).
Procedures	**Objective:** To assure that worker responsibilities are well understood, and that site-specific procedures are available in hard copy for reference.
	• Prepare (and have readily available) explicit written instructions for all aspects of chemical use, facility operation, maintenance and emergency response. • Identify and communicate precautions for all other on-site handlers of treated wood (including quality control personnel, sorters and transporters).
Signing*	**Objective:** To assure clear and accurate signing of all wood preservation use areas.
	• Identify the contents of all tanks (e.g. CCA work tank, PCP oil storage tank). • Identify the function of each tank (e.g. concentrate tank, work tank). • Prominently display personnel safety precautions and first aid procedures. • Prominently display emergency response procedures. • Prominently display emergency telephone numbers for medical aid, facility management, local environmental control agencies.
Personal hygiene and safety precautions	• Follow precautions outlined in section 5, Table 1.
Housekeeping	**Objective:** To maintain a clean, orderly site.
	• Define and practice regular housekeeping standards (suggest daily). – contain all contaminated debris, – minimize generation and accumulation of wastes, such as empty drums and containers (provide secure designated storage or dispose of in the appropriate manner). • Visually inspect for, record and report leaks routinely as defined in the facility's procedure manual (preferably daily). • Contain and repair leaks promptly.
Record keeping	**Objectives:** ◊ To provide a secondary level of control for chemical losses. ◊ To enable a rapid assessment of potential hazards, in the event of a catastrophic incident (e.g. tank rupture, fire).
	• Maintain accurate daily records for: – chemical delivery, use and inventory, – equipment condition and maintenance. • Record and compare bulk tank volumes before and after facility shutdowns in excess of two days. – if changes in volume are apparent, check for tank leaks and/or irregular practices.

*All signing is preferably done in accordance with workplace hazardous materials informations system (WHMIS) requirements. (Note: At this time, wood preservation chemicals are not yet included under WHMIS legislation.)

Table 10 Recommended General Practices for Operating Wood Preservation Facilities (continued)

Operation	Recommendations
Spill response	**Objective:** Maintain a state of readiness to implement the plan in case of a chemical spill.
	• Establish a spill contingency plan (section 12.1). • Carry out spill response drills.
Firefighting	**Objective:** To maintain a state of readiness in case of fire emergency.
	• Establish a fire contingency plan (section 12.2) and maintain a state of readiness to implement the plan in case of fire emergency (including routine checks of the pressure and proper function of firefighting equipment; drills with all affected personnel in cooperation with the local fire department). • Communicate with the local fire department about chemicals in storage and use and emergency procedures. • When a fire alarm call is made, notify firefighters of chemical quantities in stock and verify the status quo of storage locations. • Provide self-contained breathing apparatus for all personnel exposed to smoke. (Only trained firefighting personnel should be allowed at the fire scene.) • Make advance preparation to contain and properly dispose of contaminated fire residues to the greatest degree possible. – runoff water, soot and ash from fire areas are presumed to be contaminated and provision should be made to contain these residues, – analyze fire residues and involved ground soils (as applicable) to determine the need for and scope of special cleanup and disposal activities, – dispose of contaminated firefighting waters as “contaminated runoff,” – dispose of solid treated wood fire residues as “contaminated solid wastes.”

Table 11 Recommended Operating Practices for Chemical Handling and Storage

Operation	Recommendations
Unloading chemicals	**Objective:** To assure that unloading of treatment chemicals occurs in a safe manner as per section 4 of the National Fire Code of Canada (24).
	• Assure that the delivery of preservation chemicals to the plant is undertaken by personnel who are trained in emergency response procedures (as required by Transportation of Dangerous Goods Regulations). • Assure that personnel with recognized first aid training are on-site at the plant during the unloading procedure (personnel can include the truck driver). • Assure that ready access to emergency advice and aid is available during all chemical unloading periods. • Restrict access to the unloading area during chemical transfer operations. Prohibit nearby pedestrian or vehicle traffic.
Preparation of wood preservation solutions	**Objective:** To assure worker safety during handling of treatment chemicals.
	• Follow the personnel safety precautions for all procedures (Table 1). • Avoid inhalation, ingestion or skin or eye contact with all preservative chemicals. • Thoroughly empty and clean preservative containers (if applicable): – recycle rinse water (for water-borne formulations), – return containers to suppliers or reuse sound containers for storage of wastes, – dispose of unusable containers only in landfills specifically approved for such disposal (section 9).
Storage of wood preservation chemicals	**Objective:** To assure that all preservative chemicals are safely stored.
	• Assign responsibility for storage areas to trained personnel. • Label storage tanks, identifying contents by chemical name, type of solution and concentration: e.g. CCA concentrate (50%), CCA work solution (1% to 4%). • Place chemical identity placards, fire or spill emergency response procedures, personnel safety precautions and first aid procedures at storage room entrances. • Check and maintain the integrity of storage tanks and storage containers: – clean up all leaks or spills and implement remedial actions immediately. • Provide secure storage areas; restrict access to authorized personnel only.

Table 12 Recommended Operating Practices for Process Systems

Operation	Recommendation
Routine checks	Objective: To define procedural practices that will enhance environmental and worker safety.
Worker safety	Follow all precautions listed in Table 1.
Work solutions	• Regularly check and record quantities of treatment solution in storage. • Test and record solution strengths at regular intervals. • Ensure that solutions do not become excessively contaminated.
All process components	• Visually check the complete system for leaks: take immediate action to stop leaks. • Check sludge levels in retorts: clean out as appropriate, in accordance with facility policy, observe personnel safety precautions (see Table 1).
Tank vents	• Test tank vents to assure the absence of blockage (suggest once/month).
Charges	• Secure loads to avoid uncontrolled floating and jamming. • Stack loads to allow good drainage of preservative from all wood surfaces after treatment.
Treating cylinder	• Check door seals for damage and wear: replace door seals at regular intervals or as required if damaged or worn. • Check cylinder doors for proper seal after loading charges: ensure that all bolts on doors are securely fastened or that the hydraulic collar has moved to its regular endpoint.
Recycle systems	• Check filters: clean or replace if necessary.
Trams	• Clean soil and debris from trams to prevent contamination of the preservative. • Use tram design that will facilitate ready drippage during “drain” stage. • Thoroughly clean trams before alternative preservative treatments are used.
Checks during treating	Objective: To monitor the treatment system to quickly identify potential/actual problems.
System integrity	• Closely monitor process systems for leaks during initial stages of treatment. • Check for leaks or abnormal conditions throughout pressurized system at least once per shift or once per charge (whichever is more frequent). • Compare recording instrument readings with indicating gauges and thermometers. • Note malfunctions of recording devices, thermometers, gauges (including level floats) and arrange for prompt repairs. • Carefully observe pressures during treatment to make certain that maximum limits are not exceeded (maintain records of treatment cycles, tank gauge readings and chemical consumption). • Define (in writing) operator actions for abnormal situations of concern (e.g. response to equipment breakdown).
Post-treating checks	Objective: To prevent worker contact with treatment solution and with freshly discharged loads.
Retort opening	• Ensure that retorts cannot be opened when liquid and/or pressure remains. • Avoid breathing preservative mists. If airborne concentrations are unknown or are at or above TLVs, wear an approved respirator. • Wear goggles during retort door openings.
Charge removal	• Wear impermeable gauntlets during handling of freshly treated charges. • Pull charges only when the superficial excess preservative has sufficiently drained and the charges are essentially drip-free.
Load jams	• Follow standard regulatory safety procedures for tank entry. • Do not enter retorts until purged with fresh air (and cooled): if retort TLV levels exceed regulatory values or the concentration is unknown, then the attendant entering the cylinder must wear a self-contained full-face respirator mask, impermeable coveralls, boots and gauntlets, if TLV levels are below regulatory limits; wear NIOSH-approved respirator, impermeable coveralls, boots and gauntlets. • Assure presence of and constant communication with a standby attendant. • Shower immediately after tank entry.

NIOSH = National Institute for Occupational Safety and Health.

Table 13 Recommended Operating Practices for Maintenance, Cleanout and Shutdown of Treatment Systems

Operation	Recommendations
Equipment maintenance	**Objective:** To assure that equipment is maintained in a manner that will minimize releases of preservative chemicals and minimize worker exposure to them and their by-products.
	• Maintain all equipment in good operating condition. • Comply with National Fire Code of Canada 4.4.11 recommendations for maintenance. • Consider preparing explicit written maintenance procedures with assigned responsibility and accountability. • Follow all personnel safety precautions during maintenance procedures (Table 1). • Drain and/or clean wood preservation chemicals from equipment prior to maintenance: – equipment should be flushed thoroughly with water, with reuse of the water for work solution preparation (where applicable). • Use extreme caution if contaminated equipment must be welded (toxic fumes can be generated): – thoroughly clean surfaces to be welded, – wear an approved respirator when welding equipment contaminated with preservatives or their components, – provide good ventilation in the work area, – contain all sparks and remove flammable materials from the repair area.
Cleanout	**Objectives:** ◊ To prevent accumulation of preservative solutions and sludges within the treatment system. ◊ To assure worker safety during cleanout operations.
	• Observe personnel safety precautions during all procedures (Table 1). • Wash down and/or scrape drip pads at regular intervals to prevent accumulation of preservative residues. (The cleanup frequency should be determined by site-specific factors including the probability of worker exposure, vehicle traffic and washdown by rain.) – if possible, recover and reuse drainage from drip pads (or provide appropriate treatment or disposal). • Provide appropriate treatment for washwater (if applicable). • Routinely inspect sludge levels in storage and mix tanks and clean out if necessary. – during cleanup, inspect gauge floats or similar equipment within tanks. • Routinely inspect treatment cylinders for sludge accumulation and clean if necessary: – purge cylinders with fresh air sufficiently to permit entry, – if airborne concentrations are unknown, at, or above TLVs, the attendant must wear self-contained breathing apparatus, impermeable gloves, boots and coveralls, – a standby attendant must always be present and continuous communication must be provided, – follow standard safety procedures for entry of confined spaces, – prevent skin contact with sludges, – collect, drain and store contaminated material in sealed drums pending disposal (Table 4), – the attendant must shower immediately after cleaning retorts or tanks.
Alarms	• Test all alarms and safety devices at regular intervals (as specified by the manufacturer).
Long-term shutdown	**Objective:** To assure orderly shutdown prior to long-term closure.
	• Thoroughly clean all equipment that has been in contact with preservatives. • Collect all solvents and washwaters generated by cleanup operations (Table 4). • Hold solutions in closed tanks for prolonged shutdown: – drain all open tanks or sumps to closed storage tanks, – assure that temperatures in storage areas are above freezing levels or provide adequate freezing protection for all stored liquids. • In case of permanent shutdown, arrange for reuse of treatment solutions at another facility; reuse is preferable to disposal.

9 Process Emissions

The preservation of wood in treatment facilities generates liquid and solid wastes and may also produce emissions to the air. There are numerous approaches available for control, treatment and disposal of process wastes and emissions. Due to the specific characteristics of the various preservatives, designs and operating procedures for pressure or thermal facilities, the issues are generally specific to individual facilities.

Information on wastes and emissions for each type of facility, as well as their recommended disposal practices, are contained in Part II - Preservative-specific Information and Recommendations.

10 Emission and Site Monitoring

Site monitoring and assessment is recommended at wood preservation facilities, in accordance with the design and operating objectives described in this manual, to verify that chemicals are being properly managed at the site and to achieve environmental and worker health protection. Furthermore, archiving of the assessment records will provide an orderly evaluation of site decommissioning activities, if a plant shutdown does occur.

Environmental monitoring requirements for most facilities would normally be developed in consultation with the provincial environmental regulatory agency. Additional consultation with Environment Canada would be required if the facilities were to affect federally managed resources (e.g. facilities located on or adjacent to Indian lands, or adjacent to waters used by anadromous fish, such as salmon). Worker health monitoring programs may be developed in consultation with the provincial workers' compensation board and/or department of labour.

The level of detail and scope of these monitoring activities depends on site characteristics, facility design and the regulatory requirements. Components of a site environmental and worker exposure and health monitoring program are suggested in Tables 14 and 15.

Table 14 Recommended Routine Environmental Monitoring

Item	Recommendations
Authority/reporting	• Develop a site-specific monitoring plan. • Define reporting requirements. • Re-evaluate the plan if the facility expands or changes the design or operating practices.
Soils	• Consider implementing a soil monitoring program (with emphasis on unsurfaced grounds) including: – all areas where preservative chemical is routinely stored, processed or handled, – all freshly treated wood storage areas, – all treated wood storage areas, – drainage ditches or areas exposed to surface runoff (including overflow from drip pads and paved areas). • Define sampling frequency (e.g. annual), sample type (e.g. surface, core), and required analyses (e.g. constituents, detection levels, quality control) in consultation with the regulatory agency.
Surface waters	• Consider implementing a monitoring program for adjacent waterbodies: – define monitoring frequencies and required analyses (e.g. constituents, detection levels, quality control) in consultation with the regulatory agency, – define concentrations of concern.
Groundwaters	• Consider implementing a groundwater monitoring program using permanent monitoring points down-gradient of uncontained process areas and treated wood storage areas: – define well construction, – define sampling frequencies and required analyses (e.g. constituents, detection levels, quality control). • Give special attention to on-site wells used for drinking water.
Air emissions	• Identify air emission sources using data provided in workplace exposure study (Table 15). • Monitor air emissions as required by emission permits.
Liquid waste streams	• Identify liquid waste discharges (including stormwater runoff): – determine concentrations of preservative constituents, – estimate total mass rates of emissions (suggested). • Thereafter, monitor as required for all discharges governed by permits.

Table 15 Recommended Routine Workplace Monitoring

Item	Recommendations
Authority/reporting	• Develop a facility-specific plan, preferably in consultation with the regional workers' compensation board. • Define reporting formats.
Contact exposure	• Identify existing and potential sources of skin exposure by periodic walk-through inspections.
Air inhalation exposure	• Define an initial monitoring program (e.g. sampling techniques, frequency of sampling, etc.), preferably in consultation with the regulatory agency responsible for worker safety. • For the purpose of defining worker health protection measures, provide an initial evaluation of peak and average levels of preservative constituents in air at significant points of worker exposure. Include areas such as: – cylinder doors (openings), – kiln interiors, – all vents to exhausts that discharge to enclosed work areas, – receiving areas for all vents/exhausts that discharge to areas frequented by personnel, – all enclosed preservative process areas, – areas adjacent to freshly treated wood storage. • Provide for subsequent monitoring, if required by regulatory agency. • Make personnel samplers available for spot monitoring (as required) if high emission levels are suspected.
Biological monitoring	• Conduct initial screening medical exams to identify sensitive individuals (section 5). • Define a schedule for: – medical exams to confirm the absence of symptoms or signs of exposure to preservative constituents, – biological monitoring of workers for preservative constituents (e.g. arsenic concentration in urine).

11 Transportation of Preservative Solids, Solutions and Wastes

The transportation of preservative solids, solutions and the wastes generated by their use is regulated under the federal *Transportation of Dangerous Goods Act* (TDGA) and the *Canadian Environmental Protection Act, 1999* (CEPA 1999). The acts do not apply to the transportation of lumber and forestry products treated with preservatives or to treated wood wastes. The regulation of intraprovincial movement of dangerous goods is a provincial responsibility.

Transported dangerous goods must be classified according to the TDG regulations. The local Transport Canada office should be contacted for classification requirements for preservative solids, solutions and the wastes generated by their use. The treating company has to be aware that all preservatives and preservative wastes require transportation that conforms to regulations set out under the TDGA and CEPA 1999. These regulations cover, amongst others, packaging, shipping documentation, interprovincial and Canada–U.S. shipments, labeling and placarding and the reporting of dangerous occurrences.

Table 16 suggests more specific transportation procedures for preservative chemicals, which are based on good operating practice and which complement the regulations. It is the intent of these control measures to minimize the potential for accidental release in transit and to provide an effective mechanism for safely managing spills if they do occur.

Table 16 Recommended Transportation Practices for Preservative-Containing Solutions or Wastes

Feature	Recommendations
Container specifications	• Containers for transporting preservatives must be: – free from mechanical defects, – protected against physical abuse, – filled and closed in the manner prescribed for wood preservatives by the Regulations for the Transportation of Dangerous Commodities by Rail, 1986, as amended, published by the Canadian Transport Commission.
Container labelling	• Comply with TDG Act label requirements. • Affix the proper labels to each container. • Label each container on at least two sides.
Vehicle placarding	• Affix vehicle placards for the class and quantity of material shipped as designated by the TDG regulations. Note: Vehicles carrying preservative-treated commodities need not be placarded.
Securing vehicle loads (e.g. drummed wastes)	• Replace drum spouts with leak-proof bungs prior to transit. • Strap drums or blocks vertically to pallets. • Strap drums or blocks horizontally to each other. • Brace or tie down loads to prevent shifting (do not rely on the vehicle floor or sides to prevent shifting). • Ensure a stable load consistent with the vehicle floor strength. • Secure other load items to prevent drum or wrap punctures and to prevent abuse to blocks.
Responsibilities of truck driver, ship captain or railroad crew	• Know the nature of the load. • Carry suitable emergency equipment and be trained in its proper use. • Know and follow correct procedures for the reporting of accidents or spills: – immediately telephone the 24-hour contact identified in the shipping manifest, – if more than 5 kg is spilled, also telephone the emergency contact, – know and comply with any other requirements of the shipper/manufacturer. • Immediately replace lost or damaged placards or labels (carry spares). Notify the receiver of goods that preservative materials are in transit.(Note: Some provinces allow only licensed carriers to transport hazardous wastes.)
Loading procedures	• Ensure that personnel have the means and ability to transfer bulk materials safely. • Assure that all procedures involving transfer of oil or other flammable preservative solutions are in accordance with section 4.11 of the National Fire Code of Canada. • Set vehicle handbrakes securely and place wheel blocks prior to unloading. • Assure the presence of a person who knows the hazards of the preservative and who is trained and prepared to respond to spills and other emergencies. • If leakage or spillage occurs, decontaminate the vehicle prior to returning it to service. • Dispose of absorbents and spill cleanup materials as per the appropriate tables in Part II for specific preservative systems.
Shipping documents	• TDG regulations stipulate a shipping document (products) or a manifest (wastes).

TDG = Transportation of Dangerous Goods.

12 Spill and Fire Contingency Planning

Facilities using preservative chemicals should prepare a detailed contingency plan to ensure that response to spills and fires is safe and effective. Although the details of a contingency plan are facility-specific, the following provisions are typical of most spill contingency plans. A generic spill and fire contingency plan is available from the Canadian Institute of Treated Wood (CITW). This can be adapted to individual plant conditions. It is recommended that the individual facility plan be filed with the authority and/or municipality having jurisdiction.

12.1 Spill Contingency Planning

12.1.1 General Components

A contingency plan should:

I. Have policy, purpose and organizational structure.
II. Be geared to the most probable spill size.
III. Address the following phases of spill response:
    a. discovery and notification;
    b. evaluation and initiation of action;
    c. containment and countermeasures;
    d. cleanup, mitigation and disposal;
    e. documentation and cost accounting.
IV. Clearly assign duties and roles to responsible personnel and organizations.
V. Outline equipment requirements for spill control.
VI. Include procedures for updating the plan on a scheduled basis.
VII. Outline training needs for plant personnel in prevention and response.
VIII. Coordinate with other chemical spill prevention plans and procedures if appropriate.
IX. Be submitted to chemical suppliers and the cleanup consultant or contractor for review.
X. Subsequently be submitted to appropriate government agencies including the local fire department for review.

12.1.2 Implementation Capability

A contingency plan should:

I. Describe location, capability and limitations of cleanup and containment equipment.
II. Pre-arrange for use of the best available cleanup and containment equipment.
III. Identify detailed response options and strategies.
IV. Provide for training programs and regular practice sessions.
V. Identify communication requirements with police, fire departments and regulatory agencies.

VI. Describe how communications will be maintained among all parties during response operations.
VII. Describe steps to be taken as a routine precaution against spills.
VIII. Address human safety issues.
IX. Assign selected personnel to respond to public and media calls.
X. Provide for sampling of and data collection about runoff waters.

12.1.3 Environmental Protection and Other Liability Risks

A contingency plan should:

I. Identify high-risk areas and operations.
II. Discuss expected chemical and physical behaviour of spill materials.
III. Identify and prioritize sensitive environments for protection.
IV. Detail specific actions planned for minimizing damage to resources.
V. Define explicit standards for the components and extent of effective cleanup.
VI. Include provisions for responding to spills under all anticipated weather conditions.
VII. Pre-arrange all response capability needed for the estimated worst case spill.

12.1.4 Examples of Action Steps

Safety of people is a prime concern. If a spill occurs:

I. Stop the flow of preservative solutions or any liquids containing preservative components:
    a. use common sense;
    b. act quickly;
    c. shut off pumps, close valves, etc., if this can be done without risk;
    d. if applicable, shut down mechanical production systems first (e.g. lumber movement) to prevent injury.
II. Warn people in the immediate vicinity:
    a. do not allow unauthorized personnel to enter the area;
    b. provide proper protective equipment for on-site personnel;
    c. avoid any contact with skin, eyes, clothing or shoes.
III. Contain the spill:
    a. act promptly;
    b. block off drains, culverts and ditches;
    c. surround spilled material with earth, peat, straw, sand, booms or commercial sorbents;
    d. use a liquid-recovery type vacuum cleaner (or empty cylinder and vacuum pump) for recovery of pools.
IV. Obtain assistance as needed from:
    a. company personnel (advise at earliest opportunity);
    b. chemical suppliers;
    c. fire/police/public works/highways department/contractors (depending on the situation).
V. Notify applicable government agencies:
    a. prompt notification is especially important for spills that have entered or may enter receiving waters;
    b. spills to marine waters require contact with Environment Canada;

    c. spills to waterbodies with anadromous fish or spills on or adjacent to Indian lands require contact with Environment Canada and the provincial emergency program office;
    d. for all other spills, contact the provincial emergency program office.

VI. Commence recovery, cleanup, restoration action:
    a. recover pools using vacuum systems and contain recovered liquid for reuse;
    b. use an inert absorbent to complete cleanup;
    c. carry out cleanup and disposal in consultation with provincial and federal regulatory personnel.

12.2 Fire Contingency Planning

Not all preservatives or their components are flammable, and they may behave differently in fires depending on their physico-chemical characteristics. All preservative substances can emit toxic fumes during fires. The contingency plan recommendations made here are of a general nature. More information on contingency planning for specific preservatives can be found in Part II - Preservative-specific Information and Recommendations.

12.2.1 General Components

A fire contingency plan should:

I. Be prepared in consultation with local fire authorities.
II. Describe policy, purpose and organizational structure.
III. Assure that creosote, petroleum oil solutions (including PCP/oil solutions) and other flammable liquids are stored as per the National Fire Code of Canada (18).
IV. Be geared to the most probably affected area.
V. Address the following phases of fire response:
    a. discovery and notification;
    b. evaluation and initiation of action;
    c. cleanup, mitigation and disposal;
    d. documentation and cost accounting.
VI. Assure that proper fire extinguishing agents are available in adequate quantities.
VII. Clearly assign duties and roles to responsible personnel and organizations.
VIII Include procedures for updating the plan on a scheduled basis.
IX. Coordinate with other fire prevention plans and programs as appropriate.
X. Be submitted to local fire department for review.

12.2.2 Action Steps

Fire contingency plans and defined action steps will be site-specific. Nonetheless, an overall strategy should include provisions to ensure that:

I. Water can be used to cool fire-exposed containers.
II. Appropriate firefighting media are available.
III. Firefighters are protected from dusts, gas and smoke emissions by the use of respirators.
IV. An evacuation plan is prepared for populations with potential exposure to the smoke plume.
V. Contaminated runoff waters are contained.
VI. The provincial emergency program office is notified if runoff waters could have entered receiving waters.

13 Solid Wastes and Sludges

The manufacture of treated wood generates solid wastes and sludges that require careful handling and eventual disposal (see recommendations in Table 17). Preservative- and operation-specific characteristics determine the types of wastes that may be generated and the procedures to handle them. Wastes may include wood debris, treated or untreated, such as cut-offs and broken sections of product, as well as contaminated filters, wraps, solution precipitates and sludges periodically removed from sumps, cylinders, tanks and containment areas. Other wastes are sludges from wastewater treatment processes (e.g. flocculated material) and contaminated soils. The principles of waste minimization and the recovery and reuse of preservatives should be practised to the utmost to limit the volumes of waste at the plant.

A provisional code of practice for the management of post-use treated wood has been prepared by the Hazardous Waste Task Group of the Canadian Council of Ministers of the Environment (19). This would also apply to treated waste wood from preservation plants.

Table 17 Recommended Practices for Handling Solid Wastes and Sludges

Feature	Recommendations
Objective: To minimize and safely process plant wastes.	
Minimization	• Appropriately condition wood prior to treatment. • Avoid the introduction of debris, soil, snow, ice and other foreign matter from wood and trams into the treatment vessel. • Keep the treatment solution clean and ensure that solution concentrations and component balances are in accordance with acceptable standards (CAN/CSA 080). • Minimize the frequency of switching from one preservative to another in a single treatment vessel: – avoid mixing trams, – thoroughly clean vessels, ancillary piping, etc., and trams prior to a switch. • Do not exceed the stipulated limitations of process parameters (e.g. temperature).
Collection	• To be carried out by personnel trained in potential chemical hazards and appropriate handling methods. • All personal hygiene and general precautions as outlined in section 5 must be followed. • Prescribed practice for vessel entry must be observed (see Table 13, Cleanout). • Collect, drain (where appropriate) and place wastes and sludges into sealed drums.
Storage	• Provide a roofed and paved enclosure to store all wastes.
Records/reporting	• Label all drums to indicate contents (type of waste). • Maintain current and complete records (inventory) for all solid wastes and sludges stored on-site (pending disposal). • Undertake all reporting and disposal activities in accordance with applicable regulations.
Transportation	• Classify waste in accordance with the *Transportation of Dangerous Goods Act*. • Follow all instructions as outlined in Table 16.

14 References

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Part II

Preservative-specific Information and Recommendations

CHAPTER B

Chromated Copper Arsenate (CCA) Wood Preservation Facilities

Preservative-specific Information and Recommendations

This chapter must be used in conjunction with Part I, Chapter A -
General Background Information and Recommendations.

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1 Production and Use

Chromated copper arsenate (CCA) is sold throughout the world as dry mixtures of crystalline powders, as pastes or as liquid concentrates. Hartford (1) describes the mixtures, which are prepared with a variety of different ratios of chromium, arsenic and copper. The only CCA formulation currently in use in Canada is known internationally as a Type C oxide formulation, which is prepared from copper oxide and chromic and arsenic acids. The composition of a Type C formulation is stipulated in CAN/CSA 080 (2) and represented in Table 1.

The use of CCA-treated products over the last 30 years has increased significantly, particularly as a result of its acceptance in the residential markets (3). The ability to stain or paint CCA-treated wood, as well as the ease of handling treated products, resulted in widespread acceptance by homeowners for uses such as deck and patio construction, playground equipment, landscaping, foundation lumber and plywood, and fence posts. However, CCA was voluntarily withdrawn from use in residential applications and as of 1 January 2004 can be used only for industrial wood products. CCA uses for such industrial applications include the treatment of utility poles, construction timbers and marine structures.

Table 1 CCA Usage in Canada

Feature	Characteristics
Delivery format	Bulk rail and truck (liquid concentrates of 50% or 60%)
Proportions of active ingredients (2)	50% as CrO_3 19% as CuO 31% as As_2O_5
Suppliers to Canadian facilities	• Timber Specialities Ltd. (CCA prepared at Campbellville, ON, Memphis, TN, Rockhill, NC, and Tangent, OR) • Arch Wood Protection Canada, Mississauga, ON (CCA prepared at Atlanta, GA, and Valparaiso, IN) • Chemical Specialties, Inc., Charlotte, NC (CCA prepared at Gilmar, TX, Augusta, GA, and Charlotte, NC)
Estimated use quantity (1992)	• Canada: 5920 t active ingrédients (3)
Concentration of work solutions	1% to 5% as total oxides 2% solution: 4900 ppm Cr 3000 ppm Cu 4400 ppm As
Typical preservative retention in treated wood	4.0 to 12.8 kg/m^3 treated wood (0.25 to 0.8 lb/ ft^3)
Major products treated in Canada	Foundation lumber and plywood, round fence posts, utility poles, shingles and shakes, siding.

2 Physical and Chemical Properties

The components of CCA (copper, chromium and arsenic) were selected for wood preservation use because of their biocidal properties and their ability to be retained within the wood for long-term protection. The fixation mechanism of CCA within wood is complex, and the reactions involved depend on the preservative formulation and concentration, wood species, temperature and humidity conditions (4). Reaction products include insoluble chromates and insoluble arsenates of copper and chromium (5).

General physical and chemical properties of CCA (50% concentrate) are summarized in Table 2. Information was obtained from manufacturers' material safety data sheets. The data indicate that a wide variety of properties must be considered for the safe management of CCA solutions.

Table 2 Physical and Chemical Properties of CCA Concentrate Solution

Identification		
Common synonyms: ACC, Wolmanac, Osmose K-33, Woodchem C United Nations (UN) Number: 1556	Manufacturers: Arch Wood Protection Canada (Atlanta, GA; Valparaiso, IN) Timber Specialties Ltd. (Campbellville, ON) Chemical Specialties, Inc. (Charlotte, NC; Gilmar, TX; Augusta,GA)	
Transportation and storage information		
Shipping state: Liquid concentrate Concentration: 50% to 60% by weight Classification: Poisonous; corrosive oxidizer	Storage temperature: Ambient Inert atmosphere: No requirement Venting: No requirement Containers/materials: Bulk truck or train	Labels and classification: Check with the Department of Transport.
Physical and chemical properties		
Physical state: Liquid (20°C, 1 atm.) Solubility: Freely soluble (water) pH: Strongly acidic (pH 1.6 to 3.0) Vapour pressure: Non-volatile	Flottability: Dissolves readily in water Freezing point: -30°C Flash point: Not flammable Explosive limits: Not explosive or flammable Specific gravity: 1.64 (50% concentrate)	Appearance: Heavy liquid, dark brown Colour: Dark brown (concentrate) to yellow-green (dilute) Odour: Odourless
Hazard data		
Fire - *Extinguishing data*: Not combustible; common extinguishing agents can be used with fires involving CCA solutions. - *Fire behaviour*: On exposure to high temperatures may emit arsenic fumes. Containers may rupture due to chromic acid reactivity. Chromic acid may reduce the combustibility of other materials. - *Ignition temperature*: Not combustible - *Burning rate*: Not combustible	**Reactivity** - *With water :* No reaction - *With common materials*: Contact with reducing agents (such as aluminum or zinc) may liberate arsine gas (AsH_3, colourless, highly toxic) and/or may cause violent explosions due to chromic acid reactions. Contact with combustible materials (such as acetic acid, acetone, ammonia, alcohol, glycerol, hydrocarbons, hydrogen sulphide, naphthalene, sulphur and turpentine) may result in violent reactions and subsequent fire and/or explosions. - *Stability* : Stable	

3 Environmental Effects

3.1 Distribution in the Natural Environment

Copper, chromium and arsenic, the components of CCA, are natural elements that at normal background concentrations do not have discernable adverse effects on biota (Table 3).

Considerable variability in natural concentrations of copper, chromium and arsenic occurs in soils and waters. Therefore, it is important to determine background levels immediately prior to operation of a facility, to enable meaningful future assessments of pollution control at the facility.

Table 3 Typical Background of CCA Constituents (copper, chromium, arsenic) (6, 7, 8)

	Typical concentration in non-polluted environments	
Element	Surface waters (mg/L)	Soils (mg/kg)
Copper	< 0.001 to 0.04	2 to 100
Chromium	0.003 to 0.04	5 to 1000 (50 mg/kg is normal)
Arsenic	< 0.001 to 0.01	1 to 50 (up to 500 mg/kg found in sulphide deposits)

3.2 Aquatic Toxicity

In considering the aquatic toxicity of CCA, the following points should be borne in mind:

- Ratios of copper, chromium and arsenic in soils and runoff waters from CCA facilities are not necessarily consistent with their ratios in the original CCA working solutions. Depending upon various factors, it is possible that only one element may be predominant. As a result, the toxicity of each element, in addition to the toxicity of the CCA mixture, should be reviewed.

- Valence changes of arsenic, chromium or copper may occur within the environment, and those changes may reduce or enhance the toxicities of the elements. There have been no studies reported in the literature on valence interconversion of copper, chromium or arsenic in soils or groundwaters at, or in surface runoff waters from, CCA facilities. A limited study was carried out for the purposes of this document to assess arsenic speciation. The study indicated that samples of soils and waters in the vicinity of CCA facilities contained at least 97% of the original pentavalent form of arsenic (9).

Canadian limitations for arsenic, chromium and copper in aquatic environments are listed in Table 4.

The guidelines developed by a task force of the Canadian Council of Resource and Environment Ministers (12) adopt the Health and Welfare Canada drinking water quality guidelines for "raw water for drinking water supply." However, the Council's guidelines for protection of "freshwater aquatic life" are based on an independent review of the literature. The preface of the Council's report emphasized that "these guidelines do not constitute values for uniform national water quality and that their use will require consideration of local conditions" (e.g. background concentrations) (12). All of the guidelines and limitations in Table 4 are based on total concentrations of either arsenic, chromium or copper and reflect the recommended approach of many scientific reviews. These reviews indicate that the current state of knowledge does not enable water quality limitations based on either valence state or dissolved fractions in water (10).

Table 4 Canadian Limitations for Arsenic, Chromium and Copper

Element	IJC recommendations(a) Great Lakes waters	Canadian drinking water objectives(b)	Canadian water quality guidelines(e)
Arsenic	0.5 mg/L for the protection of human health	Maximum acceptable(c): 0.025 mg/L Objective(c): <0.005 mg/L	0.05 mg/L for the protection of aquatic life
Chromium	0.05 mg/L for the protection of human health	Maximum acceptable(c): 0.05 mg/L Objective(c): <0.0002 mg/L	• 0.02 mg/L for protection of fish • 0.002 mg/L for protection if the aquatic community including zooplankton and phytoplankton
Copper	0.005 mg/L for the protection of aquatic life	Maximum acceptable(d): 1.0 mg/L Objective(d): < 1.0 mg/L	For protection of aquatic life: • 0.002 mg/L Hardness 0-60 mg/L as $CaCO_3$ • 0.003 mg/L Hardness 60-120 mg/L as $CaCO_3$ • 0.004 mg/L Hardness 120-180 mg/L as $CaCO_3$ • 0.006 mg/L Hardness > 180 mg/L as $CaCO_3$

(a) Recommendations of the International Joint Commission to the governments of Canada and the United States, 1977.
(b) Health and Welfare Canada, Guidelines for Canadian Drinking Water Quality, 1989 (11). "Maximum acceptable" was defined by Health and Welfare Canada as: "Drinking water that contains substances in concentrations greater than these limits is either capable of producing deleterious health effects or is aesthetically objectionable." "Objective" is defined by Health and Welfare Canada as: "This level is interpreted as the ultimate quality goal for both health and aesthetic purposes."
(c) From Health and Welfare Canada, Recommended Limits for Chemical Substances Related to Health, 1978.
(d) From Health and Welfare Canada, Recommended Limits in Substances Related to Aesthetic and Other Considerations, 1978.
(e) Guidelines consider local conditions (e.g. background levels).

4 Human Health Concerns

Chromium, copper and arsenic are elements that occur naturally in food, water and air. Table 5 provides estimated daily intakes of these elements by the general population (15). Exposure of human beings to arsenic, copper and/or chromium at levels that exceed natural concentrations may lead to adverse health effects.

One safety objective of industrial usage of any chemical (in this case, chromium, copper and arsenic formulations) is to minimize worker exposure, ideally so that natural intake levels are not exceeded. If safeguards are not provided or implemented, a variety of human health effects may occur depending on the duration and manner of exposure; concentration of chemicals; chemical forms (valence); and the varying metabolic sensitivities of individual workers.

On the basis of information from material safety data sheets for CCA (16) and an assessment of existing literature, Table 5 outlines the possible human health effects that may result from over-exposure to CCA solutions. Extensive reviews of the potential health effects of individual elements are provided in documents from the National Research Council of Canada (6, 7, 8), the World Health Organization (17), and the International Labor Organization (18).

Table 5 The Range of Possible Effects from Exposure to CCA Solutions

		Possible health effects	
Exposure category	**Type of exposure**	**Short-term exposure**	**Long-term exposure**
General population	Estimated daily intake from food, air, water. (13)		
• Arsenic (found in foods, especially seafoods)	0.1 mg	None	None
• Copper (an essential element)	3 mg	None	None
• Chromium (in trace quantities in all foods)	0.2 mg	None	None
Properly protected worker	Minimal	None reported	None reported
Exposed worker with significant skin contact	Skin contact with work solutions or concentrates	• Skin irritation • Inflammation (7, 18)	• Ulceration (12) • Potential carcinogenic action (18, 19)
Exposure to contaminated aerosols	Inhalation of mists, droplets or aerosols of work solutions or concentrates	• Severe irritation of nose and throat (7, 18) • Irritation of eyes	• Ulceration and perforation of nasal septum upon long exposure (14) • Potential carcinogenic action (18, 19)
Ingestion	Ingestion of work solutions or concentrates	• Nausea, abdominal pain, vomiting, shock, coma. • Reported amounts that have resulted in death are 0.1 to 1 g arsenic (8, 22); 0.7 g chromium (+6) (7). These reported fatalities did not take place in CCA plants.	• Possible liver and kidney damage, jaundice, reduced white blood cells upon long-term exposure to 0.15 to 0.6 mg arsenic per day (8) • Potential carcinogenic action (18, 19).

5 Description of Preservative Application and Potential Chemical Discharges at CCA Wood Preservation Facilities

5.1 Description of Process

The impregnation of CCA into wood is carried out in pressure-treating plants (Figure 1). In 1993, 59 Canadian plants used 5920 t of CCA to treat 1.56 million m^3 (55 million ft^3) of wood products. Of these plants, 45 used CCA as the sole preservative and 14 had facilities applying one or several of the other preservatives as well (3).

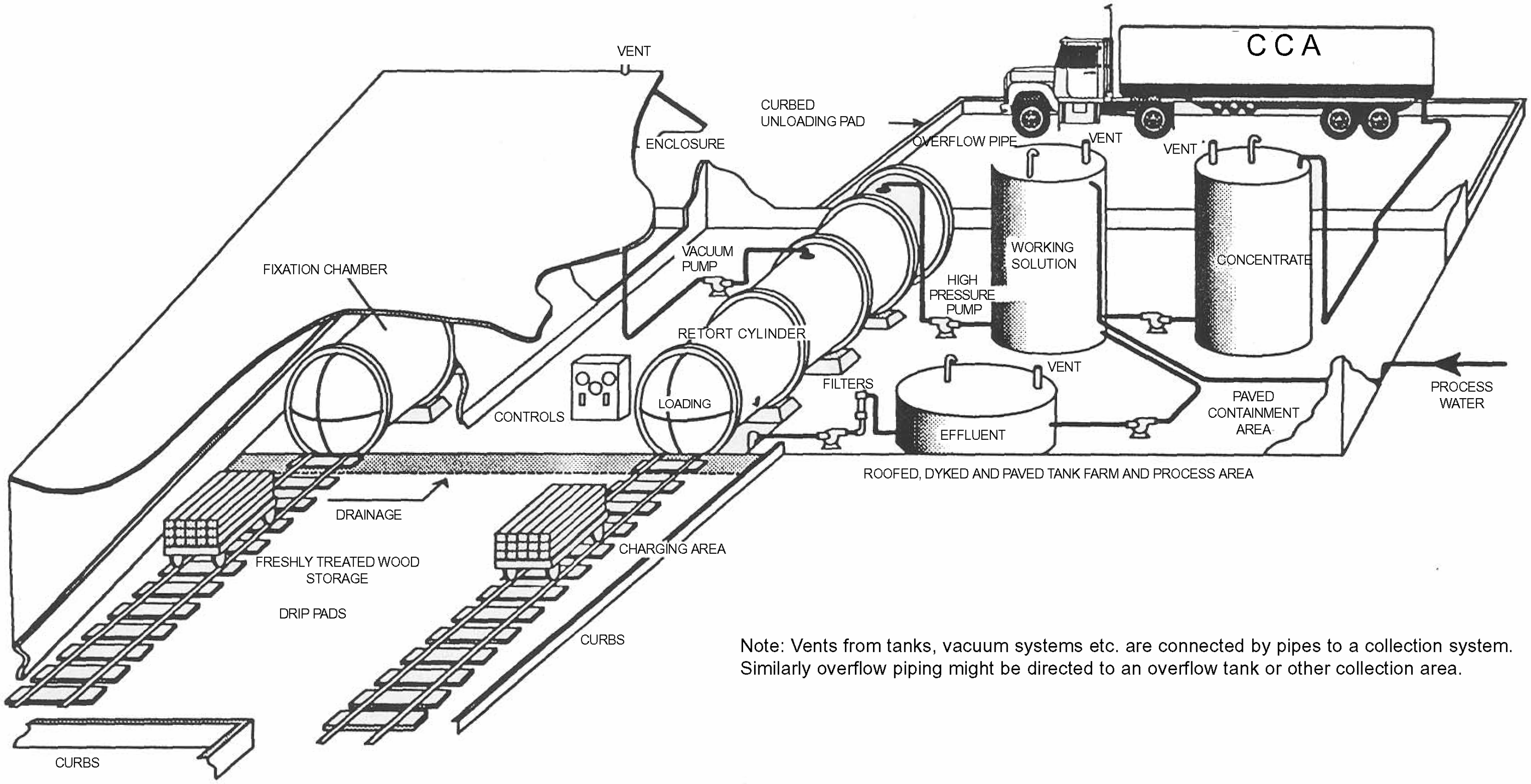
There are three suppliers of CCA (Timber Specialties, Arch Wood Protection Canada, Chemical Specialties Inc.), who all offer a high level of support services, including facility design and routine safety and consulting expertise on operations, maintenance and emergency response procedures. This approach provides a relatively high level of control over preservative use at most facilities (21). Design and operational guidance from the suppliers provides a national level of general consistency to the CCA facilities.

CCA is normally purchased as a premixed concentrate (50% or 60%) shipped by bulk truck and rail tanker. The concentrate is stored in tanks and diluted with water to a 1.5% to 5.0% strength working solution. This dilution is accomplished by pumping transfers and recirculation between bulk tanks. The working solution is then applied to the wood in a pressure cylinder, which may be up to 45 m long and 2 m in diameter. (Figure 1)

The full-cell treatment process, used to apply the preservative in CCA treatment plants, consists of the following steps:

- application of an initial vacuum to remove air from the wood cells;
- flooding with CCA working solution and pressurization (up to 1040 kPa) until the target CCA retention level is achieved;
- draining of the excess CCA working solution (to the working tank for reuse with subsequent charges);
- application of a final vacuum.

The specific treatment times and pressures are dictated by the species of wood, the type of wood product (e.g. plywood or poles) and the moisture content of the wood. A predetermined range of process parameters is defined by the applicable treatment standards (2) and quality control tests are carried out to ensure that a minimum treated product quality is achieved. Once the treated wood is withdrawn from the treating cylinder, it is either subjected to a fixation process or stored on-site for periods that generally range from days to months.



Note: Vents from tanks, vacuum systems etc. are connected by pipes to a collection system. Similarly overflow piping might be directed to an overflow tank or other collection area.

Figure 1. Conceptual diagram of a CCA pressure treating facility

5.2 Potential Chemical Discharges

CCA wood preservation plant designs and operational practices do vary, and within each plant there are various potential emission sources that may affect the adjacent environment and/or worker health. The potential sources and types of releases are illustrated in Figure 2.

Liquid Discharges

The CCA process uses water as a solvent. Therefore, drippage collected on the pad or rainwater collected in the process areas can be reused within the process. The toxicity and economics of the process chemicals have led the CCA wood preservation industry to use closed treatment systems that contain, collect and reuse the chemical mixture to the greatest possible extent. Primary elements that may be used for CCA containment and recycling at well-operated facilities are illustrated in Figure 1.

These elements include:

- paved containment surfaces and dyking of major process components including the cylinder and CCA tankage;
- containment surfaces for chemical drips from treated wood on the cylinder discharging track, that is, in the freshly treated wood storage area and fixation or kiln drying area;
- a collection sump to receive residual preservative from the cylinder (following the treatment cycle) and the accumulated contaminated precipitate runoff from other containment surfaces.

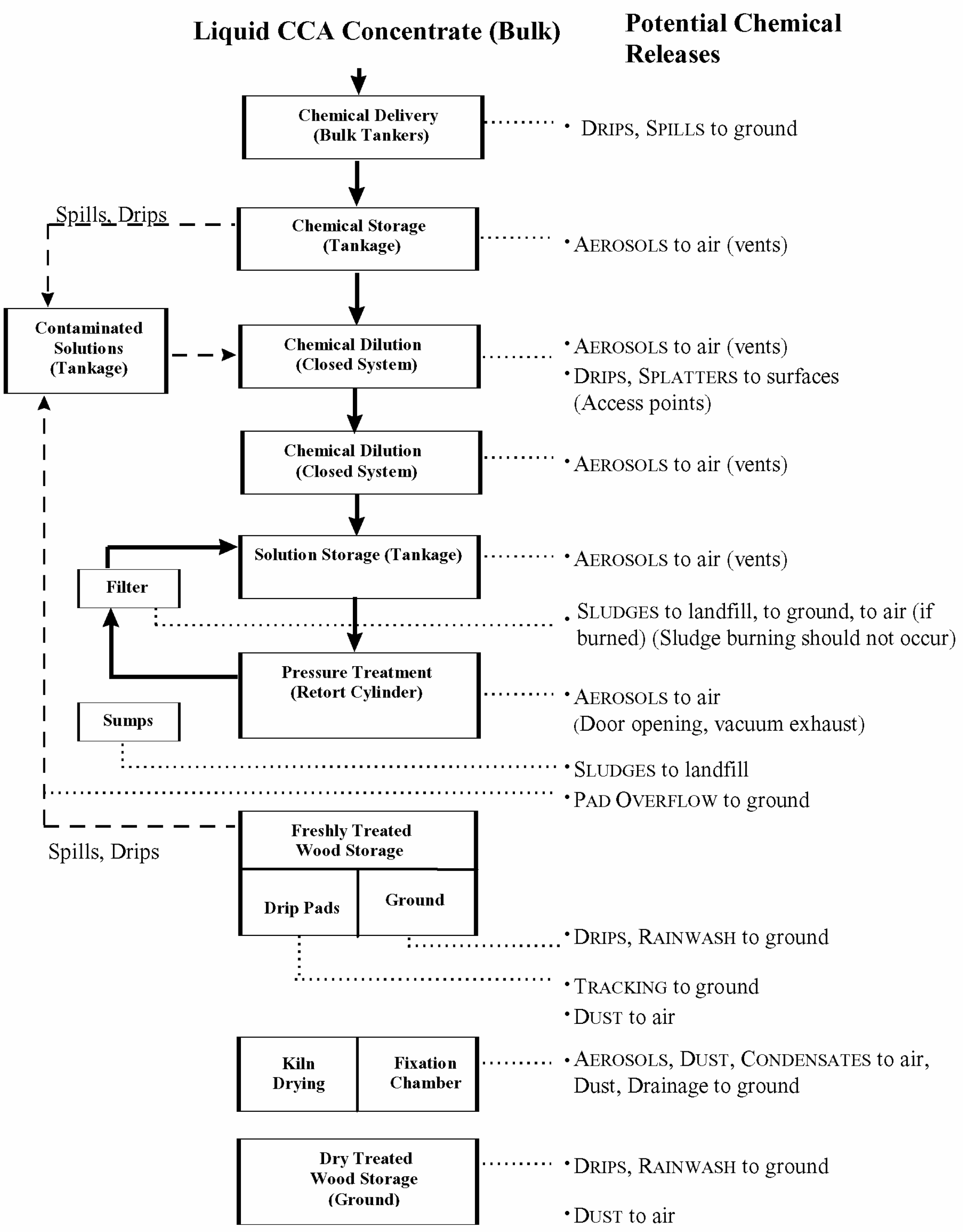
Contaminated liquids entering the sump are pumped through cartridge filters to remove dust and wood debris. The filtered solution is stored in a holding tank and returned to the process as makeup water for preparing fresh working solution for subsequent charges.

Under normal operating practices, liquid discharges from a CCA treatment facility are confined to liquids that are not contained and reused within the process. For example, stormwater runoff from unpaved and unroofed treated-product storage areas is the most common liquid discharge from many CCA treatment facilities. The quantity of copper, chromium, or arsenic in such waters depends on many factors such as quantity of precipitation, the degree of chemical fixation in the treated wood as determined by fixation time and temperature prior to the precipitation event, and soil characteristics of the storage yard. Uncontained liquid releases other than stormwater are generally confined to yard soils. Potential for groundwater contamination exists in locations where drip pads are not used in discharging areas, where the pad areas are inadequate to hold the treated wood until fixation is accomplished, or where kiln drainings are uncontained.

Solid Wastes

Solid waste generation at CCA facilities is usually minimal. During normal operating conditions, solid waste is limited to cartridge filters that are used for dust and debris removal from recycled water and to the debris and sludges that are periodically removed from the sump, cylinder and tanks. Treated wood, such as stickers, cut-offs or broken product, is another source of solid wastes.

Figure 2 Potential Chemical Releases From CCA Pressure Treating Plants



Air Emissions

Potential sources of air emissions include mists from vacuum pump exhaust, cylinder doors and tank vents. Some preservative chemical may also be entrained in emissions from fixation chambers and kilns, when the chemical in the treated product is being fixed following treatment. Several monitoring studies in the vicinity of such air emission sources have been reported in the literature, and concentrations of copper, chromium and arsenic below existing occupational health limits were reported (20, 21, 24).

5.3 Potential Effects

The actual impact of any emission depends on many factors, including the location of the wood preservation facility relative to ground or surface waters, the amount associated with the releases, the frequency of releases, and contingency measures in place at the facility.

Environmental assessments of CCA facilities (21, 24) do exist. Environmental or worker health effects are commonly not caused by "normal" CCA usage at wood preservation facilities. However, available information indicates that improperly designed and/or operated facilities do have the potential to contaminate yard, soil and groundwaters to levels that would disallow the use of such groundwaters for drinking purposes (21). Also, surface runoff waters that exceed various regulatory limits have been reported (9).

5.4 Environmental Monitoring

There have been few studies of CCA releases from wood preservation facilities to the adjacent environment. Data compiled for regulatory purposes (21) indicate that when proper precautions are not taken, groundwaters in the immediate vicinity of CCA facilities may be contaminated to levels that render the groundwaters unsafe for human use. To a limited extent, stormwater runoff from CCA facilities has also been analyzed, and the results indicate the stormwaters may contain at least one of copper, chromium or arsenic at levels in excess of existing water quality limits (9). The studies also indicate that ratios of copper/chromium/arsenic are not consistent within runoff waters. The inconsistency may be due to differences in the ability of the components to bind to the yard soils or due to different sources within the yards (i.e. stored lumber washoff versus dripped material from freshly treated loads). Additional monitoring studies are recommended to properly assess the degree of such releases.

Studies of air quality at several CCA facilities have been reported (20, 21, 24), and concentrations of arsenic, copper and chromium in those facilities were found to be below regulatory workplace standard action levels. The treatment process requires no external heat sources (except for kiln drying and in facilities applying accelerated fixation processes) and no vapours should be created. Air releases, if any, would be in the form of localized mists. The effect of a normal CCA facility on air quality of the surrounding environment is expected to be non-detectable.

6 Personnel protection

6.1 First Aid for CCA Exposure

Exposure	First action	Second action
Eye contact	• Immediately flush eyes with flowing water, occasionally lifting the upper and lower lids. • Flush eyes for at least 15 minutes.	• Use boric acid solution and cortisone ophthalmic drops. • Get medical attention.
Skin contact	• Flush contaminated area immediately with flowing water. • Subsequently remove contaminated clothing. • Continue to flush contaminated skin for at least 15 minutes.	• Get prompt medical attention if the skin becomes inflamed (redness, itchiness or pain).
Inhalation	• Immediately remove the exposed person to fresh air.	• Apply artificial respiration if breathing has stopped. • Keep the affected person warm and quiet. • Get immediate medical attention.
Ingestion	• Promptly have the exposed person drink a large quantity of milk, egg whites, gelatin solution or water if the aforementioned are unavailable (16). • Never give liquids to an unconscious person.	• Call an industrial physician or poison control centre immediately for subsequent advice. (Stomach pumping by medical personnel is desirable.) • Do not induce vomiting.
Chronic symptoms requiring medical referral	• Ulceration of the skin or mucous membrane (breaks in the skin, disintegration of tissue, pus formation). • Abdominal pains and other persistent symptoms of illness.	

6.2 Regulatory Controls

Specific limits for worker protection are generally found in provincial regulations. Most of the criteria are based on the threshold limit values (TLVs) and biological exposure indices recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH limits of exposure in the workplace for copper, chromium and arsenic are summarized in Table 6.

Table 6 Levels of Concern for CCA Exposure in the Workplace

Route of entry	Basis for recommendation	Recommendations/comments
Skin and eye contact	• CCA is corrosive. • Chromium can be absorbed through the skin. • Arsenic is a potential dermal carcinogen.	• Protective measures should be used by workers in contact with CCA concentrate (Table 7). • Avoid direct contact of skin and eyes with all CCA solutions. • Sensitive individuals should take special care to avoid exposure. *Comment* : Current material safety data sheets should always be readily available to workers.
Inhalation	ACGIH threshold limit value-time weighted averages (TWA): Arsenic* and soluble compounds: 0.01 mg As/m^3 air Copper (dusts and mists): 1.0 mg Cu/m^3 air Chromium (+6) compounds (water soluble) 0.05 mg Cr/m^3 air Arsine: 0.2 mg/m^3 of air (0.05 ppm) * U.S. OSHA has set a limit of 0.01 mg As/m^3 of air	• Full face protection and good ventilation should be used during chemical unloading and open mixing operations. • Provide respiratory protection, eye protection and good ventilation: – when welding contaminated equipment, – during any activity that might generate arsenic vapours (e.g. from exposure of CCA to reducing agents), – when CCA dust, mist or spray is present. • Self-contained breathing apparatus should be used for firefighting activities where CCA is present. *Comments*: – permissible concentrations of arsenic and chromium refer to vapours: both could occur in air as aerosols; – arsenic vapours can be formed from exposure of arsenic salts or CCA to reducing agents; – current material safety data sheets describing safety precautions should always be readily available to workers.
Ingestion	The literature reports an arsenic lethal dose range of 0.1 to 1.0 g for adults. The lowest reported lethal dose of 0.1 g (22) is equivalent to 1 g of 50% CCA solution.	• Prevent the ingestion of any quantity of CCA solutions.

Skin and Eye Contact

Chromated copper arsenate, as such, is not discussed by the ACGIH. With reference to skin and eye contact, the ACGIH provides the following conclusions in its support rationale (25) for TLV levels for individual components of CCA:

- copper salts act as irritants that may produce itchy eczema on skin and conjunctivitis or ulceration of the eye;
- hexavalent chromium may cause contact dermatitis and skin ulcers, and may be absorbed through skin to cause kidney damage.

Nonetheless, ACGIH-recommended limits for copper, chromium and arsenic are based only upon “inhalation” TLVs. These limits may not adequately take into account routes of exposure other than inhalation, and the ACGIH has suggested that in such cases “biological exposure indices may be useful as a guide to safe exposure.”

Inhalation

The ACGIH has defined TLVs for many substances based on exposure by inhalation and/or by skin exposure. The ACGIH limits for copper, chromium and arsenic are based solely on exposure by inhalation. The TLVs stipulated by the ACGIH are those “airborne concentrations of substances to which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effects.” The TLVs for copper, chromium and arsenic (26) are defined in Table 6 with the following provisos of the ACGIH:

- “The limits are intended for use in the practice of industrial hygiene as guidelines for good practices or recommendations in the control of potential health hazards and for no other use” (i.e. proof or disproof of the cause of an existing disease or physical condition).
- “The limits are not fine lines between safe and dangerous concentration.”
- “In spite of the fact that serious injury is not believed likely as a result of exposure to the Threshold Limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical.”
- “When two or more hazardous substances, which act upon the same organ system, are present, their combined effect, rather than that of either individually, should be given primary consideration.”

Since CCA wood preservation facilities exclusively use CCA water solutions, the limits as defined by the ACGIH would apply primarily to suspended aerosols, dusts or gases generated during welding. Generally, aerosols are not generated in CCA facilities at quantities that would cause worker health problems. Incidents of aerosol exposure would be more probable at improperly maintained facilities (i.e. from leaking seals) or at inadequately designed facilities (e.g. from vacuum pump discharges to the work area). Dust generation is most probable from forklifts and trucks moving on the drip pad and the yard and is also expected from cleaning operations. Frequent washdowns of pads and collection of the sump contents should minimize airborne contaminants caused by pad traffic. The International Labor Organization strongly suggests the use of wet or vacuum methods for cleaning of chromium solution spills, to prevent dispersion as airborne dust.

Ingestion

Oral intake of CCA must be avoided. Ingestion of CCA-containing liquids is unlikely if workers follow the precautions outlined in Table 7. Acceptable limits of ingestion are not prescribed by regulation since it is generally expected that any such intake will not occur.

Reported fatal single dose levels for components of CCA, include:

- 0.7 g chromium as chromium (+6) assuming a 70 kg body weight (7); and,
- 14 g copper as copper (+2). (29)

Oral toxicity values of arsenic (+5) to humans are not defined. Reported fatal doses for "arsenic" and "arsenic (+3)" have ranged from 20 to 300 mg (8, 27). The Registry of Toxic Effects (22) suggests that arsenic (+5) is more acutely toxic to rats than arsenic (+3); however, it is known that laboratory animals react to arsenic differently than humans. An absolute lethal dose to a person of arsenic (+5) as used in CCA, therefore, cannot be derived from animal data and remains unknown.

6.3 Safety Precautions

Table 7 Safety Precautions for Personnel Working with CCA Solutions

Activity	Recommendations
Objective: To ensure safe workplace practices for each activity during the treatment process.	
Unloading bulk CCA concentrate	• Wear protective apparel, including chemical goggles or face shields, impermeable gauntlets, coveralls, impermeable aprons and impermeable shoes or boots. • Prohibit foot or vehicle traffic between the point of delivery and the transport vehicle. • Place "DANGER — CCA UNLOADING" signs at each end of the transport vehicle during unloading operations. • Ensure that at least two individuals trained in handling CCA are present at all times during unloading operations (i.e. at least one person other than the truck driver; this person may include forepersons, supervisors and management employees). • Ensure that all connections are secure and leak tight. • Provide an emergency eyewash and shower in the immediate unloading area.
Preparing CCA work solutions	• Wear full face protection, impermeable gauntlets, coveralls, impermeable aprons and impermeable shoes or boots for all operations involving direct exposure to CCA concentrates. • Thoroughly clean and hose down the work area following solution preparation. • Dispose of debris and empty containers according to Table 13. • Thoroughly clean protective equipment after use. (Reuse all rinse waters for work solution preparation.) • Provide an emergency eyewash and shower in the immediate area.
Sampling procedures	• Wear eye protection and impermeable gloves when sampling CCA solutions (including full face protection with CCA concentrates). • Wear impermeable gloves when taking borings from freshly treated wood.** • Wash gauntlets and goggles immediately after completing sampling. • Wash the outside of sample containers immediately after sampling solutions. • Wash hands thoroughly after all sampling operations.

Table 7 Safety Precautions for Personnel Working with CCA Solutions (continued)

Activity	Recommendations
Cleaning cylinders, fixation chambers or storage tanks	• Follow all standard precautions for vessel entry (as per provincial health and safety regulations). • Flush vessels as required to establish safe entry conditions, or use an approved self-contained breathing apparatus prior to entry. • Wear NIOSH-approved respirators (or breathing apparatus), impermeable gauntlets and aprons (rubber or polyethylene coated) and rubber boots during all vessel entries. Select respirators with combination of acid gas/high efficiency filter cartridges. • Always have a standby attendant present. • Collect and store contaminated waste material in sealed and labelled drums. • Wash all protective equipment immediately after use (reuse all rinse waters for preparing treating solutions). • Shower after completion of cleanup tasks.
Removing treated charges from cylinders	• Wear gauntlets during door openings and when moving loads of freshly treated wood. • Avoid breathing preservative mists. Wear an approved respirator if airborne concentrations are unknown or at or above TLVs.*
Handling treated lumber	• Wear impermeable** gloves. • Wear impermeable** gloves, aprons and boots if there is potential for getting wet by CCA solution.
Handling and maintaining contaminated equipment	• Thoroughly flush equipment with water prior to handling. (Reuse rinse waters for preparing work solutions.) • Wear an impermeable** apron and boots if there is potential for getting wet by CCA solution.
Welding	Welding can produce toxic fumes. In addition to the precautions for handling and maintaining contaminated equipment: • Obtain the specific approval of the supervisor before welding. • Block or disconnect lines from tanks before initiating welding operations. • Completely drain and thoroughly rinse tanks or lines prior to welding operations. • Ensure that equipment is completely dry from cleaning solvent residues. • Wear a respirator or provide effective, local exhaust ventilation during welding to prevent potential exposure to toxic fumes. • Assume good general ventilation of the work area. • Comply with all additional provincial workplace safety rules.

* An initial workplace monitoring program as suggested in Table 15 of Part I, Chapter A - General Background Information and Recommendations will have determined the need for respirator use. The results of the program are assumed to be indicative of conditions in subsequent facility operations, unless procedural or design changes have occurred.

** Heavy-duty, lined polyvinyl chloride, nitrile/PVC, neoprene, polyethylene.

7 Design Recommendations

Tables 8, 9 and 10 present good design features specifically applicable to CCA wood preservation facilities. The recommendations made here must be used in conjunction with the basic design criteria listed in Part I, Chapter A - General Background Information and Recommendations, section 7.

Table 8 Recommended Design Features for Chemical Storage Areas

(See also Part I, Chapter A - General Background Information and Recommendations, Table 4.)

Storage format	Design feature	Recommendations
Bulk CCA liquids: • Concentrates • Working solutions • Contaminated surface runoff • Drip return	Backflow prevention	• Install backflow preventers on all waterlines at plant entry. • Use top entry of waterlines to tanks (as secondary backflow prevention). • Waterlines must comply with all applicable local codes.
	Emergency response	• Provide accessible storage for spill response equipment, absorbents (lime for concentrate, sawdust for wood solutions, drip return, runoff and personnel protection equipment.).

Table 9 Recommended Design Features for Chemical Mixing Systems

(See also Part I, Chapter A - General Background Information and Recommendations, Table 5.)

Chemical from	Design feature	Recommendations
CCA bulk concentrate	Location/shelter	• Locate in a contained, enclosed, heated area, particularly if sub-freezing temperatures are encountered during operation.
	Spill prevention	• Interlock high-level alarms to tank feed pumps.

Table 10 Recommended Design Features for Freshly Treated Wood Drip Areas

(See also Part I, Chapter A - General Background Information and Recommendations, Table 8.)

Design feature	Recommendations
Objective	To minimize losses of preservative chemicals from treated wood by: • providing proper conditions for preservative fixation in freshly treated wood; • controlling the generation and disposal of contaminated runoff waters.
Drip protection	• Provide for sufficient contained and roofed storage or transfer area for freshly treated wood prior to application of the fixation process. Completely enclosed drip areas are preferred. • Provide completely contained and roofed drip area for material undergoing fixation at ambient conditions. (Roofing may not be necessary in areas of low precipitation.)
Fixation	• Where freshly treated wood is stored prior to removal to an accelerated fixation unit or a protected, contained storage area for fixation under ambient conditions, a paved (impermeable), contained and roofed area should be provided for such storage. • The storage area for fixation under ambient conditions should be paved (impermeable), contained and roofed, with provisions for recovery of drips and any infiltrating precipitation. • Provide the fixation chamber with an impermeable floor for collection of drips and a drip collection system.

Recommended design features for treated wood storage areas can be found in Part I, Chapter A - General Background Information and Recommendations, Table 9.

8 Operational Recommendations

The recommendations for good operating practices listed in Tables 12 and 13 must be used in conjunction with those in Part I, Chapter A - General Background Information and Recommendations, section 8.

The objectives are to protect both workers and the environment from harmful exposure to CCA solutions.

Table 11 Recommended Operating Practices for Chemical Handling and Storage

(See also Part I, Chapter A - General Background Information and Recommendations, Table 11.)

Operation	Recommendation
Storage of CCA solutions (concentrates)	• Prevent contact of CCA concentrate with reducing agents (including aluminum, brass and zinc) or with organic combustibles (e.g. gasoline, kerosene, oil).

Table 12 Recommended Operating Practices for Freshly Treated Wood

(See also Part I, Chapter A - General Background Information and Recommendations, Table 9.)

Objective	To ensure that ground contamination due to preservative drippage or leaching is minimized.
Treatment process	• Apply an effective final vacuum after completion of the pressure cycle.
Fixation	• Fixation is a temperature- and humidity-sensitive process that may take from several hours at 60 to 70°C to more than 4 or 5 months at 5°C. Under ambient conditions (21°C) it may take up to 100 days (typically 4 to 5 days) to fix completely in accordance with the AWPA-A3/11 standard method (4). Accelerated fixation at elevated temperatures (e.g. 70°C) requires the presence of high humidity conditions to ensure optimum fixation results. • Accelerated fixation is preferred to fixation under ambient conditions. It can be achieved by application of elevated temperatures, while maintaining high humidity conditions. Conditions promoting drying do not result in optimum fixation levels. • Where interim storage is necessary, freshly treated wood should be held in a protected, contained area until moved into the accelerated fixation unit or to the protected area used for fixation under ambient conditions. • The treated wood should be released from the protected fixation area only after CCA fixation has been verified by an acceptable test method (e.g. CAN/CSA 080 and AWPA-A3/11). • See also Table 10, Fixation.

9 Process Emissions and Disposal

9.1 Control, Treatment and Disposal

Potential process emission sources from CCA wood preservation facilities are described in section 5.2 and Figure 2. The main categories of process wastes or emissions that may be encountered at CCA facilities and recommended disposal methods are presented in Table 14.

9.2 Liquids Containing CCA

Liquid Process Wastes

Liquid process wastes (i.e. >1% total oxides) are not normally discharged from CCA plants. Liquid solutions (such as drips and washwaters) containing CCA are routinely collected and reused as makeup in preparing new treatment solutions. If unusual circumstances (such as prolonged plant shutdown) prevent on-site reuse, transport to another CCA facility (for reuse) should be arranged and disposal should be considered only as a last alternative.

If disposal is unavoidable, specific approval must be obtained from the appropriate regulatory agency. If no suitable means of disposal are readily available, then the solutions should be sealed in leakproof metal containers, labelled and stored in a secure area.

Contaminated Storm Runoff

Contaminated storm runoff should be minimized. Various approaches can be used including assurance of proper final vacuum to remove any excess CCA solution from treated wood; use of roofed areas for treated product storage; assurance of proper fixation methods and minimization of surface deposits (keeping solutions clean) prior to storage in the open environment; and containment and reuse of storm runoff waters. In areas of high rainfall, complete containment may not be economically feasible and roofing might be preferred. If the release of CCA-contaminated runoff is required, guidance (and possibly specific approval) should be obtained from the appropriate provincial environmental regulatory agency. Control specifications may depend on factors such as the volume and frequency of the discharge and the sensitivity of the receiving environment. The discharge of CCA-contaminated runoff into waters inhabited by fish is subject to the provisions of the federal *Fisheries Act*.

9.3 Solids with High CCA Concentrations

For the purposes of this document, solids with “high CCA concentrations” include sludges from sumps and cylinders and the disposal of cartridge filters used to filter recycled waters. For general information on handling solid wastes and sludges consult Part I, Chapter A - General Background Information and Recommendations, section 13.

Recovery of the components (copper, chromium, arsenic) represents an ideal option that is currently not available in Canada. The preferred means of disposal for CCA-contaminated sludges and cartridge filters is solidification and burial in an approved, secure (hydrogeologically isolated) chemical landfill. It is the responsibility of the waste generator to obtain and comply with approvals requested by the jurisdiction in which the disposal site/facility is located.

Solids with high concentrations of CCA should be drained and stored in leakproof, sealed containers while awaiting disposal. Contaminated solids should be stored in a specifically designated area, which is curbed and lined with impermeable material. The area should be roofed to protect the wastes from precipitation. Any seepage or leachate generated at the site must be contained.

Incineration of CCA-contaminated materials is not recommended because of formation of toxic combustion by-products.

9.4 Miscellaneous Solid Wastes

Miscellaneous solid wastes (e.g. empty concentrate drums, stickers or cuttings from CCA-treated lumber) from CCA wood preservative plants may be disposed of at designated sanitary landfills as approved by the provincial regulatory agency. CCA concentrate drums should be triple rinsed with water prior to disposal, and the rinse water should be used for the preparation of working solutions.

9.5 Air Emissions

Air emissions at CCA facilities are normally localized; effects, if any, would be restricted to workers at the facilities. Air emissions from CCA facilities include:

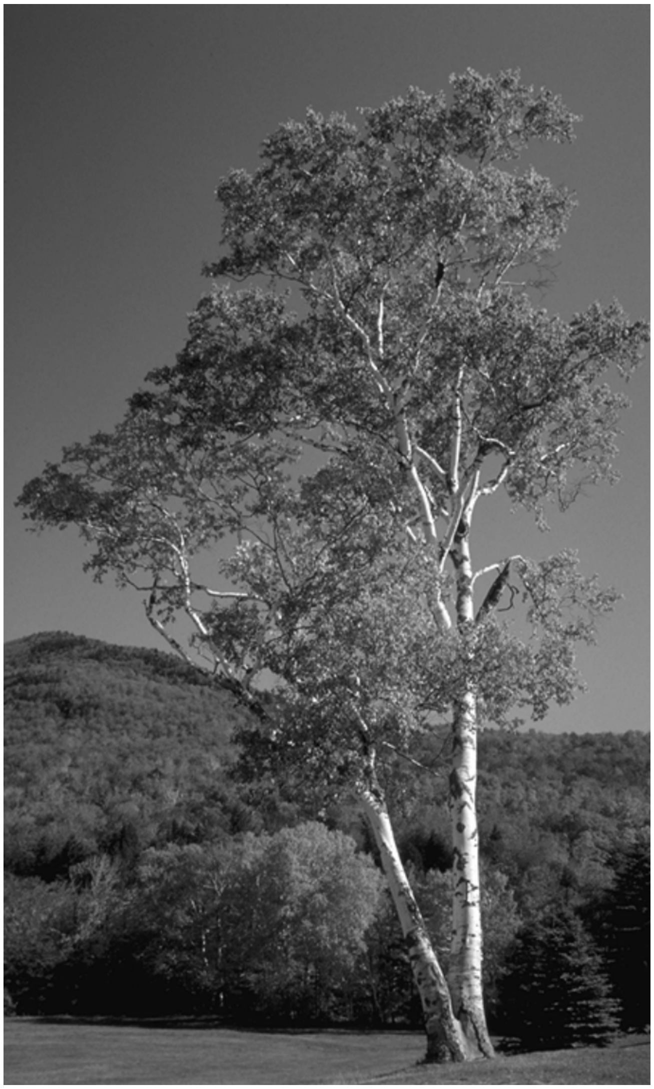
- exhaust from kilns;
- exhaust from tank vents;
- mists from vacuum pump discharge;
- mists from opening of retort cylinder doors;
- mists from accelerated fixation facilities.

Monitoring of mists (20, 24) in the vicinity of several CCA retort cylinder door openings has shown that, at the studied sites, arsenic, chromium and copper concentrations were below published ACGIH TLVs (26). Emissions from vacuum pump discharges have not been evaluated. However, evidence of CCA releases from such discharges were reported in an Environment Canada study (21). Some facilities discharge vacuum pumps through simple traps to condense and collect emissions (21). This practice is highly recommended. A study on air emissions from kilns treating CCA-impregnated wood indicated that releases of chromium, copper and arsenic were frequently below detection limits (28).

Table 13 Recommended Disposal Practices for Wastes Contaminated with CCA

(See also Part I, Chapter A - General Background Information and Recommendations, Table 18.)

Waste category	Examples	Recommendations
Liquid CCA solution	• CCA concentrates • CCA work solutions • Drips from freshly treated lumber • Washwaters	• Reuse as makeup for work solutions (standard practice at CCA plants).
Contaminated solid wastes	• Debris and bottom sludge from storage tanks and sumps • Debris and sludges from recycle filters • Any wood waste or wood debris that has contacted CCA concentrate	• Drain, drum and dispose of in a secure chemical landfill with prior approval of the regulatory agency. • Do not burn CCA-contaminated wastes (toxic gases may be formed).
Miscellaneous solid wastes	• Empty concentrate drums. • Scraps, cuttings and shavings from CCA-treated lumber • Solid fire residues	• Rinse drums thoroughly and dispose of in designated sanitary landfills subject to approval by the regulatory agency. • Dispose of other waste in sanitary landfills subject to approval by the provincial regulatory agency.
Contaminated storm runoff	• Any storm runoff or contaminated liquid discharge that contains arsenic at concentrations exceeding 0.5 mg/L, or whose discharge results in concentrations of arsenic in the receiving environment exceeding 0.025 mg/L, or whose discharge results in concentrations of copper in the receiving environment exceeding 0.005 mg/L. * Note: These limits are subject to change.	• Prevent or minimize contamination of storm runoff. • Contain and reuse contaminated runoff as makeup for work solutions (to the greatest possible extent). • Monitor surface water discharges (in consultation with the provincial regulatory agency) to assess contaminant concentrations.
Firefighting water runoff	• As above (**contaminated storm runoff**)	• Contain and reuse contaminated runoff as makeup for work solutions (to the greatest possible extent). • If reuse is not practical, consult with the provincial regulatory agency to determine acceptable disposal.



10 Emission and Site Monitoring

Site monitoring and assessment are recommended at CCA facilities, in accordance with the design and operating objectives described in this document, to verify that wood preservative chemicals are properly managed at the site and to ensure environmental and worker health protection.

Environmental monitoring requirements would normally be developed in consultation with provincial regulatory agencies and, where applicable, Environment Canada. However, worker health monitoring programs may be developed in consultation with a provincial workers' compensation board and/or department of labour.

A program needs to ensure that adequate monitoring sites and frequencies are selected and that the preservative constituents, detection levels and quality control are defined. The appropriate components of a site and worker exposure monitoring program are contained in Part I, Chapter A - General Background Information and Recommendations, Tables 14 and 15.

11 Transportation of CCA Solutions and Wastes

The transportation of CCA solutions and wastes is regulated under the federal *Transportation of Dangerous Goods* (TDG) *Act*. The act does not apply to the transportation of treated wood or treated wood wastes. The regulation of intraprovincial movement of dangerous goods is a provincial responsibility.

The stipulated transportation procedures are abstracted in Part I, Chapter A - General Background Information and Recommendations, section 11.

12 Spill and Fire Contingency Planning

Preparedness for emergencies is essential in any wood preservation plant. Hence, facilities using CCA should prepare and have readily available detailed contingency plans to ensure that response to spills and fires is quick, safe and effective.

12.1 Spill Contingency Planning

In addition to the recommendations in the corresponding section 12.1 of Part I, Chapter A - General Background Information and Recommendations, contaminated sawdust or soils, etc., should be neutralized with lime before the cleanup efforts begin (use a ratio of 91 kg lime per 227 L CCA 50% concentration -200 lb./50 gal.).

12.2 Fire Contingency Planning

Components of CCA and CCA solutions are not flammable. Tests comparing toxicity of combustion products from CCA-treated wood versus untreated wood showed no differences in acute toxicity (29).

However, precautions should be taken in the event that a fire occurs in the vicinity of CCA solutions. One of the components, chromic acid, is a strong oxidizer and may increase the fire threat upon dispersal on wood floors, pallets, cotton packaging or cartons. Arsenic acid may be converted to more toxic reduced forms of arsenic upon exposure to high temperatures. It is, therefore, important that CCA wood preservation facilities devise an adequate contingency plan for fire protection.

In addition to the recommendations in the corresponding section 12.2 in Part I, Chapter A - General Background Information and Recommendations, the following action steps should be included in the plan:

- use of water blanket area.
- use of water spray to suppress toxic dust and gases and to keep temperatures of other oxidizable material below that for ignition.
- use of any fire protection agents except soda-acid.
- ashes from CCA-treated wood should be considered a hazardous waste and disposed of as such.

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CHAPTER C

Ammoniacal Copper Zinc Arsenate (ACZA) Wood Preservation Facilities

Preservative-specific Information and Recommendations

This chapter must be used in conjunction with Part I -
General Background Information and Recommendations

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1 Production and Use

Ammoniacal copper zinc arsenate (ACZA) is a waterborne formulation that is prepared on-site at wood preservation facilities by mixing and oxidizing arsenic acid, copper oxide, zinc oxide ammonium hydroxide, ammonium bicarbonate and water. There is only one Canadian facility using ACZA. At this facility, arsenic acid, zinc oxide and copper oxide are received in drums, and ammonia is delivered by bulk tank trucks. The drum weights of arsenic acid, zinc oxide and copper oxide are such that operators prepare batches of ACZA by mixing the contents of equal numbers of drums. The drums are labelled with the trade name "Chemonite."

ACZA is first prepared as a concentrate: usually 8% to 13% total oxide as CuO, ZnO and As_2O_5 at a ratio of 2:1:1. The components of the ACZA solutions are blended in a closed mixing tank equipped with a scrubber. First the bottom of the tank is filled with water. Then the solids — copper, zinc and ammonium bicarbonate — are added to form a slurry. Next, concentrated aqua ammonia is blended into the slurry, whereafter the arsenic acid can be added. The entire mix is aerated to oxidize the copper. This is associated with a rise in temperature. Once the oxidation is complete (10 to 72 hours) the remaining aqua ammonia is added. For preparation of work solutions (2% to 7% total oxides) the concentrate is diluted with requisite amounts of water. Drum rinsate and effluent water can be used for this purpose.

ACZA is particularly suited for treatment of refractory wood species such as Douglas fir. Major products are construction timbers (e.g. highway timbers), fence posts and marine structures. Although ACZA was developed in Canada and has been used in the United States for over a decade, it was introduced commercially into Canada only in 1999.

Table 1 ACZA Usage in Canada

Feature	Characteristics
Delivery format	as individual components: • Copper oxide/drums (@ 136 kg – 140 kg) • zinc oxide bags (@ 23 kg) • 75% arsenic acid liquid/drums (@ 205 kg) • 29% aqua ammonia liquid (bulk)
Suppliers to Canadian facilities	• J.H. Baxter, San Mateo, CA (arsenic acid, copper oxide and zinc oxide) • local suppliers (ammonia)
Concentration of work solutions	Concentrate 8% to 13% as total oxides Work solutions 2% to 7%
Typical preservative retention in treated wood	4.0 to 24 kg/m^3 treated wood (0.25 to 1.5 lb/ft^3)
Major products treated in Canada	Construction timbers, marine structures, utility poles

2 Physical and Chemical Properties

Copper, zinc and arsenic are used because of their biocidal properties and their ability to be retained by wood for long-term protection. Ammonium bicarbonate facilitates the dissolution of the metals. Ammonium hydroxide is used as a solvent carrier for copper zinc arsenate, and once the ammonia evaporates from the wood the copper and zinc arsenate precipitate in the wood cells in forms that remain highly resistant to leaching. The use of ammonia also prevents copper from corroding iron components in the treating equipment. The physical and chemical properties of ACZA and its constituents are outlined in Tables 2 to 7.

Table 2 Physical and Chemical Properties of ACZA Solution

Identification		
Common synonyms: Chemonite, ACZA (Ammoniacal copper zinc arsenate)	**Manufacturers:** Prepared on-site from copper zinc oxide and arsenic acid provided by J.H. Baxter and Co. (San Mateo, CA) and aqua ammonia from local suppliers.	
Transportation and storage information		
Prepared state: Treating solution on-site (not transported) **Concentration:** (by wt., as oxides) Concentrates, 8% to 13% Working solution, 2% to 7% **Classification:** Poisonous, corrosive liquid	**Storage temperature:** Ambient **Hoses:** Use PVC, rubber, polyethylene steel or stainless steel fittings only. **Venting:** Provide scrubbing to meet air discharge regulatory limits. **Containers/materials:** Plastic, steel or steel polylined	**Labels and classification:** Check with the Department of Transport.
Physical and chemical properties		
Physical state: Liquid (20°C, 1 atm.) **Density:** 2% solution, 1.02 8% solution, 1.06 **Vapour pressure (27ºC):** 2% solution, 21 mm Hg 8% solution, 72 mm Hg **Solubility:** Freely soluble (water)	**Floatability:** Mixes with water **Freezing point:** -3°C to -5°C **Flash point:** Not applicable (see ammonia) **Explosive limits:** Mixtures of ammonia in air (16%-25% by volume) in an enclosed space can ignite or explode if sparked or exposed to temperatures exceeding 650°C (1200°F)	**Colour:** Light blue **Odour:** Sharp, characteristic odour (50 ppm threshold) **pH:** 2% solution, 10.2 8% solution, 12.0
Hazard data		
Fire *Extinguishing data*: Liquid is non-flammable. Most extinguishing agents can be used on fires involving ammonium hydroxide and arsenic acid. *Fire behaviour*: Liquid not flammable. Mixtures of ammonia and air can ignite or explode (see above). When exposed to fire, the liquid solution releases ammonia gas as well as copper, zinc and arsenic fumes. *Ignition temperature*: Not flammable as liquid; ammonia is flammable at 649°C. *Burning rate*: Not applicable.	**Reactivity** *With water* : No reaction, soluble. *With common materials*: Copper, tin and zinc alloys are readily corroded. Reacts with acrolein, acrylic acid, chlorosulphonic acid, dimethyl sulphate, halogens, hydrochloric acid, hydrofluoric acid, nitric acid, sulphuric acid, oleum, propylene oxide and silver nitrate. Avoid contact with aluminum or zinc. Strong reducing conditions may produce arsine gas. *Stability*: Stable	

Table 3 Physical and Chemical Properties of Ammonium Hydroxide

Identification

Common synonyms:
Aqua ammonia
Ammonium hydrate
Ammonium solution
Ammonia water
Ammonia liquor

Manufacturers:
Canadian Industries Ltd., Courtright, Ontario
Canadian Fertilizers Ltd., Medicine Hat, Alberta
Cominco Ltd., Carseland, Alberta
Cyanamid Canada Ltd., Niagara Falls, Ontario
Simplot Chemical Ltd., Brandon, Manitoba
Western Co-op Fertilizers Ltd., Calgary, Alberta

Transportation and storage information

Shipping state: Liquid

Concentrations:

Grade A: 29.4%		USP: 27%-29%
B: 25%		CP: 28%
C: 15%		

Classification: Poisonous, corrosive

Storage temperatures: Ambient

Hoses: Use PVC, rubber, polyethylene steel or stainless steel fittings only.

Venting: Provide scrubbing to meet air discharge regulatory limits.

Containers/materials: Plastic bottles, drums, tank trucks, tank cars (steel or steel polylined). Use all iron or SS pumps (no copper alloys, brass or bronze).

Labels: Check with the Department of Transport.

Physical and chemical properties

Physical state: Liquid (20°C, 1 atm.)

Vapour pressure:

Ammonia	(0°C)	(27°C)
10%	31 mm Hg	159 mm Hg
20%	88 mm Hg	310 mm Hg
30%	238 mm Hg	786 mm Hg

Solubility: Freely soluble (water)

Floatability: Floats and mixes with water

Flash point: Flammable as ammonia

Explosive limits: Mixtures of ammonia in air (16%-25% by volume) in an enclosed space can ignite or explode if sparked or exposed to temperatures exceeding 650°C (1200°F).

Colour: Colourless

Odour: Sharp, characteristic odour (50 ppm threshold)

Vapour density: 0.6

Specific gravity: 0.90 (15.5°C)

Hazard data

Fire

Extinguishing data: Liquid is non-flammable. Most extinguishing agents can be used on fires involving ammonium hydroxide and arsenic acid.

Fire behaviour: Liquid not flammable. Mixtures of ammonia and air can ignite or explode (see above). When exposed to fire, the liquid solution releases ammonia gas.

Ignition temperature: Not flammable as liquid; ammonia is flammable at 649°C.

Burning rate: Not applicable.

Reactivity

With water: No reaction, soluble

With common materials: Copper, tin and zinc alloys are readily corroded. Reacts with acrolein, acrylic acid, chlorosulphonic acid, dimethyl sulphate, halogens, hydrochloric acid, hydrofluoric acid, nitric acid, sulphuric acid, oleum, propylene oxide and silver nitrate. Avoid contact with aluminum or zinc.

Stability: Stable

Table 4 Physical and Chemical Properties of Arsenic Acid (75% Solution)

Identification

Common synonym:
Orthoarsenic acid

Manufacturer: ASARCO Inc., New York, NY
Supplied by J.H. Baxter and Co. (San Mateo, CA)

Transportation and storage information

Shipping state:
Liquid concentrate
Concentration: 75% by weight
Classification: Poisonous liquid

Storage temperature: Ambient
Venting:
Liquid solution requires venting.

Containers/materials:
Plastic (poly) drums
Labels: Check with Department of Transport.

Physical and chemical properties

Physical state:
Liquid (20°C, 1 atm.)
Vapour pressure:
No available information
Solubility: Freely soluble (water)
Floatability:
Sinks and dissolves in water

Molecular weight:
150.9 ($H_3AsO_4 \cdot ½H_2O$)
Specific gravity: 1.8-2.0
Boiling point: 160°C
Vapour density:
No information
Flash point: Not flammable
Explosive limits:
Not applicable

Colour/appearance:
Clear liquid; yellowish-brown nitrogen dioxide may be released.
Odour: Odourless

Hazard data

Fire

Extinguishing data: Liquid is non-flammable. Most extinguishing agents can be used on fires involving ammonium hydroxide and arsenic acid.

Fire behaviour: Liquid not flammable. At high temperatures the liquid will volatilize, releasing toxic fumes.

Ignition temperature: Not flammable.

Burning rate: Not applicable.

Reactivity

With water : No reaction; soluble

With common materials: Contact with reducing agents will liberate arsine (AsH_3), a colourless, highly toxic gas.

Reacts vigorously with fluoride and chlorate. Avoid contact with aluminum or zinc.

Stability: Stable

Table 5 Physical and Chemical Properties of Copper Oxide

Identification		
Common synonym: Cuprous oxide	**Manufacturer**: J.H. Baxter and Co. (San Mateo, CA)	
Transportation and storage information		
Shipping state: Solid **Concentration**: 95% by weight purity **Classification**: Not regulated	**Storage temperature:** Ambient **Venting:** No requirement **Containers/materials:** Steel drums	**Labels:** Not regulated.
Physical and chemical properties		
Physical state: Solid (20°C, 1 atm.) **Molecular weight:** 143 **Specific gravity:** 5.75-6.09 (20°C) **Solubility:** 0.02 mg/100 ml (water/0°C) **Floatability:** Sinks in water	**Melting point:** 1235°C **Boiling point:** 1800°C **Vapour density:** Not applicable **Vapour pressure:** Not applicable **Flash point:** Not flammable **Explosive limits:** Not generally applicable; dust can explode under some conditions.	**Colour:** Reddish-brown **Odour:** Odourless
Hazard data		
Fire *Extinguishing data*: Solid is not flammable. *Fire behaviour* : Solid is not flammable. *Ignition temperature*: Not flammable. *Burning rate*: Not applicable.	**Reactivity** *With water*: No reaction. *With common materials*: Reacts violently with acetylene, ammonium nitrate, bromates, chlorates, iodates, chlorine, ethylene oxide, fluorine, hydrogen peroxide and hydrogen sulphide. *Stability*: Stable	

Table 6 Physical and Chemical Properties of Zinc Oxide

Identification	
Common synonym: Zinc oxide	**Supplier**: J.H. Baxter and Co. (San Mateo, CA)
Transportation and storage information	
Shipping state: Solid (powder) **Concentration**: 97.2% by weight (purity) **Classification**: Not regulated	**Storage temperature:** Ambient
Physical and chemical properties	
Physical state: Solid (20°C, 1 atm.) **Specific gravity:** 5.6 **Solubility:** Less than 1% in water **Colour:** Buff yellow	**Vapour density:** Not applicable **Vapour pressure:** Not applicable **Flash point:** Not applicable **Odour:** None
Hazard data	
Fire *Extinguishing data*: Solid is not flammable. *Fire behaviour* : Solid is not flammable. *Ignition temperature*: Not flammable. *Burning rate*: Not applicable.	**Reactivity** *With water* : No reaction. *With common materials*: None known. *Stability*: Stable

3 Environmental Effects

3.1 Distribution in the Natural Environment

Ammonia, copper, zinc and arsenic are found naturally in the environment. Typical background levels of ACZA constituents are listed in Table 7. Considerable variation occurs in natural concentrations of copper, zinc and arsenic in soils and waters (1,2). Because ammonia concentrations may vary both spatially and temporally (3), it is important to determine background levels immediately prior to operation of a facility, to enable meaningful future assessments of pollution control.

Table 7 Typical Background Levels of ACZA Constituents (1, 3, 4, 29)

Element	Typical concentration in non-polluted environments	
	Surface waters (mg/L)	Soils (mg/kg)
Copper (Cu)	< 0.001 to 0.04	2 to 100
Arsenic (As)	< 0.001 to 0.01	1 to 50 (up to 500 mg/kg found in sulphide deposits)
Ammonia (NH_3)	<0.1	1 to 5 ppm (as NH_4^+)
Zinc (Zn)	<0.05	60

3.2 Aquatic Toxicity

In considering the aquatic toxicity of ACZA, the following points should be borne in mind:

- Ammonia, copper, zinc and arsenic acid are individually delivered and handled at ACZA facilities; therefore, the toxicity of each as well as the toxicity of the ACZA mixture must be considered.

- The valence of arsenic, copper and zinc may change in the environment, and these changes may reduce or enhance the toxicities of the elements. No studies have been reported in the literature on valence inter-conversion of copper, zinc or arsenic in soils, groundwaters or surface runoff waters at or from ACZA facilities. Nonetheless, it is known that reduced forms of copper rarely occur in aqueous environments (1). A limited study to assess arsenic speciation in samples of soils and waters in the vicinity of CCA facilities showed that the samples contained at least 97% of the original pentavalent form of arsenic (5). A similar predominance of the pentavalent form is assumed at ACZA facilities.

The guidelines and limitations for copper, zinc and arsenic noted in Table 8 are based on total concentrations, reflecting the recommendations of many scientific reviews that indicate that the current state of knowledge does not enable water quality limitations to be based on either valence state or dissolved fractions in water (7).

Table 8 Canadian Limitations for Arsenic, Ammonia, Copper and Zinc

Element	IJC recommendations[(a)] Great Lakes waters	Canadian drinking water objectives[(b)]	Canadian water quality[(e)]
Arsenic	0.05 mg/L for the protection of human health	Maximum acceptable[(c)]: 0.025 mg/L	0.05 mg/L for protection of aquatic life
Ammonia	0.02 mg/L (non-ionized) for the protection of aquatic life	Maximum acceptable[(d)]: 0.01 mg/L	Guideline depends on pH, e.g. 2.2 mg/L at pH 6.5 to 7.5 and 10°C; 0.45 mg/L at pH 8.5 and 10°C[(f)]
Copper	0.005 mg/L for the protection of aquatic life	Maximum acceptable[(d)]: 1.0 mg/L Objective[(d)]: < 1.0 mg/L	For protection of aquatic life: 0.002 mg/L hardness 0 to 60 mg/L as $CaCO_3$ 0.003 mg/L hardness 60 to 120 mg/L as $CaCO_3$ 0.004 mg/L hardness 120 to 180 mg/L as $CaCO_3$ 0.006 mg/L hardness > 180 mg/L as $CaCO_3$
Zinc		5.0 mg/L	0.03 mg/L for protection of aquatic life

(a) Recommendations of the International Joint Commission to the governments of Canada and the United States, 1977. Arsenic refers to total arsenic and does not distinguish between (+3) and (+5) forms.

(b) (8) Health and Welfare Canada. *Guidelines for Canadian Drinking Water Quality*, 1989. Arsenic refers to total arsenic and does not distinguish between (+3) and (+5) forms.
"Maximum acceptable" is defined as: "Drinking water that contains substances in concentrations greater than these limits is either capable of producing deleterious health effects or is aesthetically objectionable."
"Objective" is defined as: "This level is interpreted as the ultimate quality goal for both health and aesthetic purposes."

(c) From Health and Welfare Canada, Recommended Limits for Chemical Substances Related to Health, 1978.

(d) From Health and Welfare Canada, Recommended Limits in Substances Related to Aesthetic and Other Considerations, 1989.

(e) Guidelines consider local conditions (e.g. background levels) (4).

(f) Guideline is based on total ammonia concentration (non-ionized and ionized forms).

4 Human Health Concerns

Ammonia, copper, zinc and arsenic are found naturally in food, water and air. Tables 9 to 13 provide estimated daily intakes of these elements by the general population (9).

One safety objective of industrial usage of any chemical (in this case, ammonia, copper, zinc or arsenic) is to minimize worker exposure to the chemical, ideally so as not to exceed acceptable intake levels. If safeguards are not provided or implemented, then a variety of human health effects may occur depending on the duration and manner of exposure, concentration of chemicals, chemical forms (valence), and varying metabolic sensitivities of individual workers.

Table 9 Potential Health Effects of Exposure to Ammonium Hydroxide

		Possible health effects	
Exposure category	**Type of exposure**	**Short-term exposure**	**Longer-term exposure**
General population	Estimated daily intake of ammonium hydroxide from food, air, water		
	Food: 571 mg (9)	None	None
	Water: 0.4 mg (9)	None	None
	Air: 0.46 mg (9)	None	None
Properly protected worker	Minimal	None reported	None reported
Exposed worker with significant skin or eye contact	Skin or eye contact with 28% solutions. Eye contact is very dangerous; cornea can be perforated (11)	• Skin irritation. • Contact of several minutes can cause corrosive damage (12).	• Not applicable
Exposure to contaminated aerosols	Inhalation of vapours	• Severe irritation of nose and throat at 400 ppm (13) • Irritation of eyes at 700 ppm (13)	• No serious effects for exposures of less than 1 hour.
		• Convulsive coughing at 1720 ppm (13)	• May be fatal after 0.5-hour exposure.
		• Respiratory spasm and asphyxia at 5000 to 10 000 ppm (13)	• Rapidly fatal for exposure causing these symptoms.
Ingestion	Ingestion of work solutions or concentrates	• Nausea, abdominal pain, vomiting, shock, coma • Death may occur from ingestion of more than 30 mL (1 oz.) of 25% solution (12)	• Not applicable.

Table 10 Potential Health Effects of Exposure to Copper Oxide (9, 12, 14)

		Possible health effects	
Exposure category	**Type of exposure**	**Short-term exposure**	**Longer-term exposure**
General population	Estimated daily intake from food, air, water: 3 mg	None	None
Properly protected worker	Minimal	None reported	None reported
Exposed worker	Repeated or prolonged skin and eye contact	• Copper salts act as irritants, which may produce itchy eczema on skin, and conjunctivitis or ulceration of the eyes.	
Exposure to contaminated aerosols or dusts	Repeated or prolonged inhalation of mists, droplets or aerosols	• Irritation of the nose and upper respiratory tract	• Perforation of nasal septum
Ingestion	Oral LD_{50} (rat) > 5 g/kg of body weight (15). This suggests a fatal oral dose for humans is greater than 350 g.	• Metallic taste, nausea, gastrointestinal problems	• Possible kidney damage, jaundice

Table 11 Potential Health Effects of Exposure to Arsenic Acid (9, 11, 13, 16)

		Possible health effect	
Exposure category	**Type of exposure**	**Short-term exposure**	**Longer-term exposure**
General population (Arsenic in foods, especially seafoods)	Estimated daily intake from food, air, water: 0.11 mg	None	None
Properly protected worker	Minimal	None	None
Exposed worker with significant skin contact	Repeated or prolonged skin contact	• Skin inflammation, redness, pain, burns, peripheral neuropathy	• Dermatitis, increased pigmentation, skin eruptions, cancer (17, 18)
Significant exposure to contaminated aerosols or dusts	Repeated or prolonged inhalation of mists, droplets or aerosols	• Sore throat, coughing, vomiting, weakness, thirst	• Carcinogenic (10, 16, 18)
Ingestion	Ingestion of solution containing >130 mg of arsenic	• Weakness, nausea, abdominal pain, vomiting, diarrhea, death*	• Carcinogenic (10, 16, 18)

* Historical information reports death from doses of 0.1 to 1.0 g arsenic (8, 16, 18).

Table 12 Potential Health Effects of Exposure to Zinc (29, 30, 31)

		Possible health effects	
Exposure category	**Type of exposure**	**Short-term exposure**	**Longer-term exposure**
General population	Estimated daily intake from food, air, water: 5-22 mg/day	None	None
Properly protected worker	Minimal	None reported	None reported
Exposed worker with significant skin contact	Repeated or prolonged skin contact	Eye and respiratory irritation	
Exposure to contaminated aerosols or dusts	Repeated or prolonged inhalation of mists, droplets and aerosols	Eye and respiratory irritation, metal fume fever	Anaemia
Ingestion	Oral LD_{50} (rat) 350 mg/kg of body weight. This suggests a fatal oral dose for an adult human of 24.5 g	Metallic taste, nausea, vomiting, diarrhea	Interference with the utilization of copper and iron and cholesterol concentrations

Table 13 Potential Health Effects of Exposure to ACZA Solutions

		Possible health effects	
Exposure category	**Type of exposure**	**Short-term exposure**	**Longer-term exposure**
Properly protected worker	Minimal	None reported	None reported
Exposed worker with significant skin contact	Skin and eye contact with work solutions or concentrates	• Skin irritation • Inflammation • Eye damage	• Potential carcinogenic action (10, 17).
Exposed worker with significant inhalation	Inhalation of mists, droplets or aerosols of work solutions or concentrates	• Severe irritation of nose and throat	• Potential carcinogenic action (10, 18).
Ingestion	Ingestion of work solutions or concentrates	• Nausea, abdominal pain, vomiting, shock, coma • Death may occur if the absorbed amount of solution contains more than 130 mg arsenic or ammonia, equivalent to 30 mL of 25% solution. • Animal tests have indicated that the LD_{50} of 8% ACZA concentrate is 1000 to 1500 mg/kg body weight (20). It is assumed that the LD_{50} for ACZA would be similar. (No actual data for ACZA are available.)	• Possible liver and kidney damage, jaundice, reduced white blood cells upon long-term exposure to 0.15-0.6 mg arsenic per day (11) • Potential carcinogenic action (10, 18).

5 Description of Preservative Application and Potential Chemical Discharges at Ammoniacal Copper Zinc Arsenate Wood Preservation Facilities

5.1 Description of Process

There is only one pressure treatment facility utilizing ACZA in Canada. At that plant the arsenic acid, copper and zinc oxides are purchased from J.H. Baxter (San Mateo, California). Ammonia is purchased locally.

The specific treatment times and pressures are dictated by the species of wood, the wood product and the moisture content of the wood. A predetermined range of process parameters is defined by the applicable treatment standards (24). Good practice, after the impregnation cycle, includes applying heat and a prolonged vacuum to remove ammonia. Ammonia loss causes precipitation of the active ingredients in the wood. Quality control tests are carried out to ensure that a minimum treated product quality is maintained.

5.2 Potential Chemical Discharges

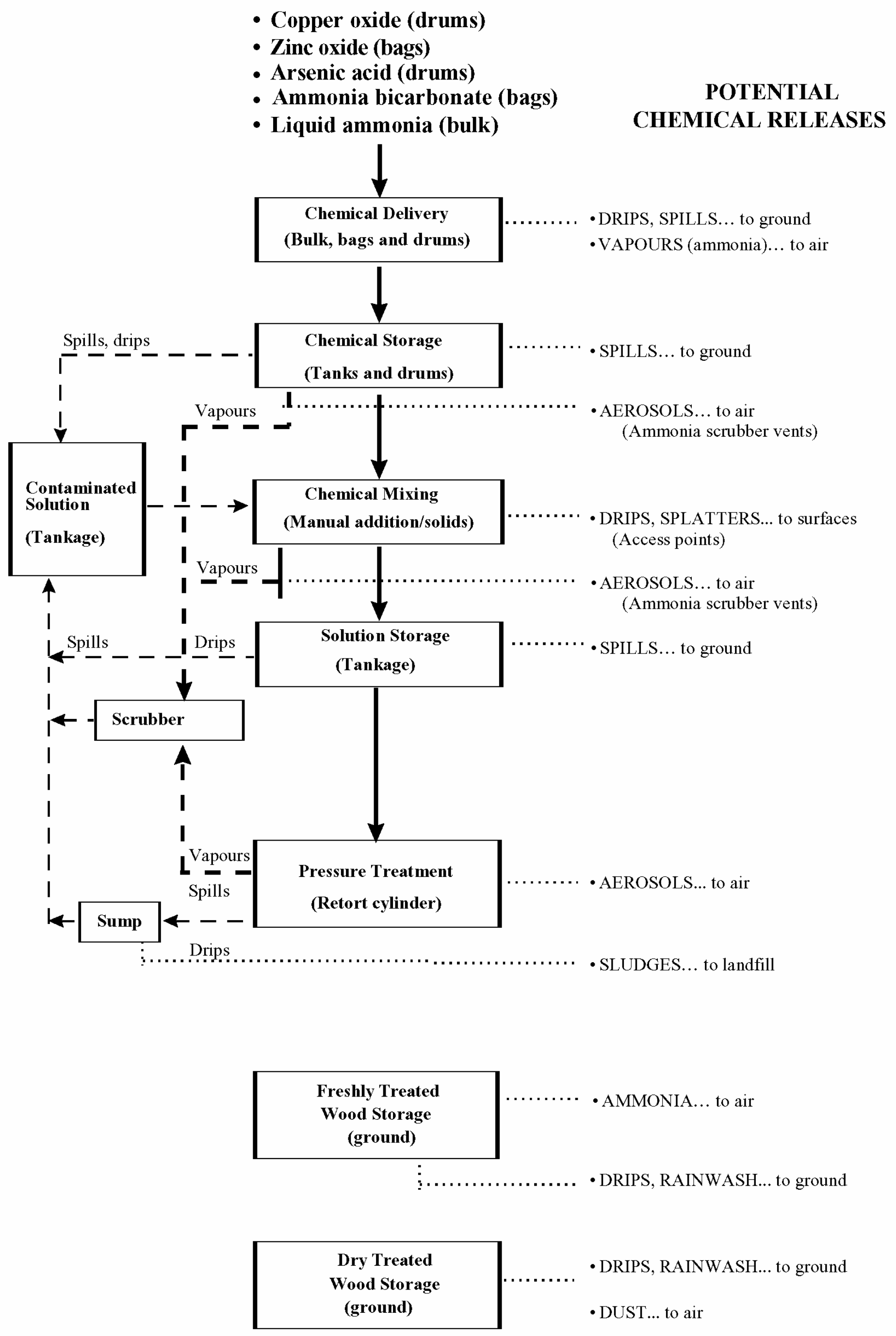
Based on the plant design and operational practices, various potential emission sources exist that may affect worker health and/or the environment. The potential sources and releases are illustrated in Figure 1.

Liquid Discharges

The ACZA process uses water-borne ingredients and can be operated as a "closed system." Dripped solution or contaminated storm runoff water can be reused in the process. Primary facility design features that should be used for ACZA containment and recycling include:

- paved containment surfaces and dyking of major process components including the cylinder and ACZA tankage;

Figure 1 Potential Chemical Releases From ACZA Pressure Treatment Facilities



- containment surfaces for chemical drips from treated wood on the cylinder discharging track and in the freshly treated wood storage area;
- a collection sump to receive residual preservative from the cylinder (following the treatment cycle) and the accumulated contaminated runoff from other containment surfaces. This material can then be reused in the treatment process following filtration to remove dust and debris.

Under normal operating practices, the most common potential sources of contaminated liquid discharges from an ACZA facility are stormwater runoff waters from unpaved and unroofed treated-product transfer and storage areas. The quantities of ammonia, copper, zinc or arsenic in these waters depend on many factors, including quantity of precipitation, elapsed fixation time and temperature prior to a precipitation event, and soil characteristics of the storage yard. Uncontained liquid releases other than stormwater are generally confined to yard soils, particularly those locations near drip pads in charging/unloading areas and when freshly treated wood is not stored on containment surfaces. These contaminated yard soils have potential for causing groundwater contamination.

Solid Wastes

Solid waste generation at ACZA facilities is small. During normal operating conditions, solid waste sources are limited to cartridge filters and traps, which are used to remove dust and debris from recycled waters, and to debris that is periodically removed from the sump, cylinder and tanks. Treated wood debris, such as splinters, stickers and cut-offs, are another source.

Air Emissions

The use of aqueous ammonia implies a significant potential for ammonia emissions at the ACZA facility, if proper controls are not in place. Potential sources of ammonia releases include storage tank vents, ACZA mixing tank hatches and vents, vacuum pump exhausts, vapours released when retort cylinder doors are opened, and from freshly removed wood charges. Scrubbers should be used to control ammonia releases from plant equipment. Potential sources of copper, zinc and arsenic emissions include mists from vacuum pump exhaust, cylinder doors and tank vents. Air emissions are generally intermittent and restricted to localized areas.

Arsenic and copper concentrations in localized areas around ACA plants have been reported to be below occupational health limits; however, ammonia emissions in the vicinity of ACA retort cylinder doors during openings and near freshly treated wood could exceed existing occupational health limits (14). The conditions in an ACZA facility are considered to be similar.

5.3 Potential Effects of Chemical Discharges

The actual impact of any chemical release depends on many factors, including the location of the wood preservation facility relative to ground or surface waters, the amount of preservative released, the frequency of releases and contingency measures in place at the facility.

There have been no documented environmental or worker health effects as a result of "normal" ACZA usage at wood preservation facilities. It can be assumed that improperly designed and/or operated facilities do have the potential to contaminate site soils and groundwaters to levels that would prevent the use of such groundwaters for drinking.

Human health effects could occur as a result of improper controls during manual preparation of ACZA, exposure to minor spills and residues in working areas, and improper handling of treated products.

6 Personnel Protection

6.1 First Aid

When exposure to a chemical occurs, the severity and speed of damage to human health depends on the concentration. The general rule is as follows: high concentration demands the highest level of protection. Immediate response is required if a worker is exposed to aqua ammonia, arsenic acid or ACZA concentrate or work solutions. Tables 14 to 18 outline first aid measures for exposure to ACZA and its constituents.

Table 14 First Aid for Exposure to ACZA or Ammonium Hydroxide

Exposure	First action	Second action
Eye contact	• Immediately flush eyes with flowing water, occasionally lifting the upper and lower lids. • Flush eyes for at least 30 minutes.	• Get medical attention.
Skin contact	• Flush contaminated area immediately with flowing water, while removing soaked clothing or articles in contact with the skin. • Continue to flush contaminated skin for at least 15 minutes.	• Get prompt medical attention if the skin becomes inflamed (redness, itchiness or pain).
Inhalation	• Immediately remove the person to fresh air (coughing and sneezing occur almost immediately after excessive inhalation of ammonia fumes).	• Apply artificial respiration if breathing has stopped. • Keep the affected person warm and quiet. • Get immediate medical attention.
Ingestion	• Give conscious victim a large quantity of water or milk. Never give liquids to an unconscious person. • Induce vomiting.	• Call an industrial physician or the poison control centre immediately for subsequent advice.* (Stomach pumping by medical personnel is desirable.)

* First aid personnel should periodically verify up-to-date response measures with chemical suppliers and/or industrial physicians.

Table 15 First Aid for Arsenic Acid Exposure

Exposure	First action	Second action
Eye contact	• Immediately flush eyes with flowing water, occasionally lifting the upper and lower lids. • Flush eyes for at least 15 minutes.	• Use boric acid solution and cortisone ophthalmic drops. • Get medical attention.
Skin contact	• Flush contaminated area immediately with flowing water. • Subsequently remove soaked clothing or articles in contact with the skin. • Continue to flush contaminated skin for at least 15 minutes.	• Get prompt medical attention if the skin becomes inflamed (redness, blisters, itchiness or pain).
Inhalation*	• Immediately remove the exposed person to fresh air.	• Apply artificial respiration if breathing has stopped. • Keep the affected person warm and quiet. • Get immediate medical attention.
Ingestion	• Promptly have the exposed person drink a large quantity of saltwater solution (one tablespoon of salt per glass of warm water). Induce vomiting until the vomit fluid is clear.** Never give liquids to an unconscious person. • After the vomit fluid is clear, have the exposed person drink two tablespoons of epsom salt or milk of magnesia in water, followed by plenty of milk or water.	• Call an industrial physician or the poison control centre immediately for subsequent advice.** (Stomach pumping by medical personnel is desirable.)

* Inhalation effects are more probable if arsenic acid contacts active metals such as zinc; the subsequent reaction can produce toxic arsine gas.

** First aid personnel should periodically verify up-to-date response measures with chemical suppliers and/or industrial physicians.

Table 16 First Aid for Zinc Oxide Exposure

Exposure	First action	Second action
Eye contact	• Immediately flush eyes with water at least 15 minutes.	• Get medical aid for any irritation.
Skin contact	• Wash with soap and water or waterless hand cleanser.	• Get medical attention if skin reaction occurs.
Inhalation	• Relocate victim to fresh air.	• Lay patient down and keep warm. Get medical attention.
Ingestion	• Drink copious amounts of milk or water.	• Get medical attention.

Table 17 First Aid for Copper Oxide Exposure

Exposure	First action	Second action
Eye contact	• Immediately flush eyes with flowing water, occasionally lifting the upper and lower lids. • Flush eyes for at least 15 minutes.	• Use boric acid solution and cortisone ophthalmic drops. • Get medical attention.
Skin contact	• Thoroughly wash the contaminated skin.	• Get prompt medical attention if the skin becomes inflamed.
Inhalation	• Immediately remove the exposed person to fresh air (coughing and sneezing occur almost immediately after excessive inhalation of copper dust).	• Get immediate medical attention.
Ingestion	• Ingestion of copper is highly improbable. If ingestion does occur, have the affected person drink large quantities of water and induce vomiting. Never give liquids to an unconscious person.	• Call an industrial physician or the poison control centre immediately for subsequent advice.*
Chronic symptoms requiring medical referral	• Ulceration of the skin or mucous membrane (breaks in the skin, disintegration of tissue, pus formation). • Abdominal pains and other persistent symptoms of illness.	

* First aid personnel should periodically verify up-to-date response measures with chemical suppliers and/or industrial physicians.

Table 18 First Aid for Ammonium Bicarbonate Exposure

Exposure	First action	Second action
Eye contact	• Flush with water for at least 15 minutes.	• Get medical attention.
Skin contact	• Wash with soap and water or waterless hand cleanser.	
Inhalation	• Relocate patient to fresh air.	• Get medical attention.
Ingestion	• Drink milk or water to dilute.	• Get medical attention.

6.2 Regulatory Controls

Most regulatory criteria established by worker protection agencies are based on the threshold limit values (TLVs) and biological exposure indices recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). ACGIH regularly reviews and revises the TLVs. The reader should always consult the latest version to remain current on any changes. The ACGIH-recommended limits for ammonia, copper, zinc and arsenic are summarized in Table 19.

Table 19 Levels of Concern for ACZA Exposure in the Workplace

Route of entry	Basis for recommendation	Recommendations/comments
Skin and eye contact	• ACZA solutions and ammonia are corrosive. • Arsenic is a skin carcinogen.	• Protective measures should be used by workers in contact with ACZA concentrate (Table 20). • Avoid direct contact of skin and eyes with all ACZA solutions and ingredients (14). • Sensitive individuals should take special care to avoid exposure. *Comment*: Workers need to familiarize themselves with all current material safety data sheets.
Inhalation	ACGIH TLV-time weighted averages (TWA): Arsenic* and its soluble compounds: 0.01 mg As/m^3 air Copper (dusts and mists): 1.0 mg/m^3 air Ammonia: 18 mg/m^3 air (25 ppm) Arsine: 0.2 mg/m^3 of air (0.05 ppm) Zinc oxide (dust): 10 mg/m^3 Arsenic is a lung carcinogen.	• Full face protection and good ventilation should be used during chemical unloading and open mixing operations. • Provide respiratory protection, eye protection and good ventilation: – during the ammonium hydroxide unloading and mixing operation and when removing charges, – when welding contaminated equipment, – during any activity that might generate arsenic vapours (e.g. from exposure of ACZA to reducing agents), – when ACZA mist or spray is present. • Self-contained breathing apparatus should be used for firefighting activities where ACZA is present. *Comments*: – permissible concentrations of arsenic refer to vapours: arsenic could be present in aerosols or dusts; – arsenic gas can be formed from exposure of arsenic salts or ACZA to reducing agents; – current material safety data sheets describing safety precautions should always be readily available to workers.
Ingestion	The literature reports an arsenic lethal dose range of 0.1 to 1.0 g for adults. The lowest reported lethal dose of 0.1 g is equivalent to 2 g of 5% ACZA solution.	• Prevent the ingestion of any quantity of ACZA solutions.

* U.S. OSHA has set a limit of 0.01 mg As/m^3 of air.

Skin and Eye Contact

The ACGIH does not provide a recommended limit for ACZA, as such. For skin and eye contact with individual components of ACZA, the ACGIH provides the following comments (18):

- A TLV of 25 ppm ammonia has been selected to protect against irritation to eyes and the respiratory tract and to minimize discomfort among unaccustomed workers. A short-term exposure limit of 35 ppm is suggested.

- Copper salts act as irritants and can produce itchy eczema on skin, and conjunctivitis or ulceration on the eye. However, a TLV for copper salts is based on inhalation.
- Adequate skin and eye protection is required during the handling of all acids, including arsenic acid. ACGIH-recommended limits for arsenic acid are based on "inhalation" TLV.

In cases where ACGIH-recommended limits (e.g. for copper and arsenic) are based only upon "inhalation" as the route of exposure, these limits may not adequately take into account other routes of exposure. The ACGIH has suggested that in such cases "biological exposure indices may be useful as a guide to safe exposure" (18).

Inhalation

The ACGIH has defined TLVs for many substances based on exposure by inhalation and/or by skin exposure. The ACGIH limits for copper and arsenic are based solely on exposure by inhalation. The TLVs are stipulated by the ACGIH as those "airborne concentrations of substances to which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effects." The short-term limit is defined as “a 15-minute TWA exposure, which should not be exceeded at any time during the work day.” The TLVs for ammonia, copper, zinc and arsenic (18) are defined in Table 19 with the following provisos of the ACGIH:

- "The limits are intended for use in the practice of industrial hygiene as guidelines for good practices or recommendations in the control of potential health hazards and for no other use" (i.e. proof or disproof of the cause of an existing disease or physical condition).
- "The limits are not fine lines between safe and dangerous concentration."
- "In spite of the fact that serious injury is not believed likely as a result of exposure to the Threshold Limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical."
- "When two or more hazardous substances, which act upon the same organ system, are present, their combined effect, rather than that of either individually, should be given primary consideration."

Ingestion

Oral intake of ACZA must be avoided. Ingestion of ACZA-containing liquids is unlikely if workers follow the safety precautions outlined in Table 20. Upper limits of ingestion are not prescribed by regulation, since it is generally expected that no such intake will occur. Reported fatal single dose levels for components of ACZA, include:

- 30 mL of 25% ammonia solution (12);
- 1.5 to 3.5 g of Cu as Cu (+1) (26).

No oral toxicity values for arsenic (+5) - AsV - to humans are defined. Reported fatal doses for "arsenic" and "arsenic (+3) -AsIII-" have ranged from 20 to 300 mg (12, 16). The Registry of Toxic Effects (26) suggests that arsenic (+5) is more toxic to rats than arsenic (+3); however, it is known that laboratory animals react differently to arsenic than do humans. The lethal toxicity to humans of arsenic (+5) as used in ACZA, therefore, remains unknown; however, because AsV is partially metabolised into AsIII , its potential toxicity should be assumed to be as high as that of AsIII.

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6.3 Safety Precautions

Table 20 Safety Precautions for Personnel Working with ACZA Solutions

Consult the pesticide label for ACZA for any additional or more stringent protective requirements.

Objective: To ensure safe workplace practices for each activity during the treatment process.

Activity	Recommendations
Unloading bulk ammonium hydroxide	• Wear protective apparel including face shields, impermeable gauntlets, coveralls, impermeable aprons and impermeable shoes or boots. Suitable materials are rubber, vinyl, polyvinyl chloride, neoprene, Buna-N, natural rubber and polyethylene. • Prohibit foot or vehicle traffic between the point of delivery and the transport vehicle. • Place "DANGER—AMMONIA UNLOADING" signs at each end of the transport vehicle during unloading operations. • Ensure that at least two individuals trained in handling ACZA are present at all times during unloading operations (i.e. at least one person other than the truck driver; may include forepersons, supervisors and management employees). • Ensure that all connections are secure and leak tight. • Provide an emergency eyewash and shower in the immediate unloading area.
Unloading drums of arsenic acid, copper and zinc oxides, and ammonium bicarbonate	• For arsenic acid, provide chemical goggles, impermeable gauntlets, full-length impermeable aprons/suit. Suitable materials are rubber, vinyl, polyvinyl chloride, neoprene, Buna-N, natural rubber and polyethylene. • Provide canister-type full face masks for spill response. • Prohibit foot or vehicle traffic in the delivery area. • Provide adequate equipment for safe, controlled drum and bag handling. • Do not drop drums or bags.
Preparing ACZA work solutions	• Wear full face protection mask with ammonia canister, impermeable gauntlets, coveralls, impermeable aprons, and impermeable shoes or boots for all operations involving direct exposure to ACZA solutions and chemical ingredients. Suitable materials are rubber, vinyl, polyvinyl chloride, neoprene, Buna-N, natural rubber and polyethylene. • Thoroughly clean and hose down the work area following solution preparation. • Dispose of debris and empty containers according to Table 30. • Thoroughly clean protective equipment after use. (Reuse all rinse waters for work solution preparation.) • Provide an emergency eyewash and shower in the immediate area.
Sampling procedures	• Wear eye protection and impermeable gloves when sampling ACZA solutions (including full face protection with ACZA solutions). Suitable materials are rubber, vinyl, polyvinyl chloride, neoprene, Buna-N, natural rubber and polyethylene. • Wear impermeable gauntlets when taking borings from freshly-treated wood. Suitable materials are rubber, vinyl, polyvinyl chloride, neoprene, Buna-N, natural rubber and polyethylene. • Wash gauntlets and goggles immediately after completing sampling. • Wash the outside of sample containers immediately after sampling solutions. • Wash hands thoroughly after all sampling operations.

Table 20 Safety Precautions for Personnel Working with ACZA Solutions (continued)

Activity	Recommendations
Cleaning cylinders or storage tanks	• Follow all standard precautions for vessel entry (as per provincial health and safety regulations). • Flush vessels as required to establish safe entry conditions, or use an approved self-contained breathing apparatus prior to entry. • Wear NIOSH-approved respirators (or breathing apparatus as above), impermeable gauntlets and aprons (rubber or polyethylene coated) and rubber boots during all vessel entries. Select respirators in consultation with chemical suppliers or provincial work safety agency. • Always have a standby attendant present. • Collect and store contaminated waste material in sealed and labelled drums. • Wash all protective equipment immediately after use (reuse all rinse waters for preparing treating solutions). • Shower after completion of cleanup tasks.
Removing treated charges from cylinders	• Wear gauntlets during door openings and when moving loads of freshly treated wood. • Do not breathe preservative mists. Wear an approved respirator if airborne concentrations are unknown or at or above TLVs.*
Handling treated lumber	• Wear impermeable** gloves. • Wear impermeable** gloves, apron and boots if there is potential for getting splashed by ACZA solution.
Handling and maintaining contaminated equipment	• Thoroughly flush equipment with water prior to handling. (Reuse rinse waters for preparing work solutions.) • Wear an impermeable** apron and boots if there is potential for getting splashed by ACZA solution.
Welding	Welding can produce toxic fumes. In addition to the precautions for handling and maintaining contaminated equipment: • Obtain the specific approval of the plant supervisor before welding. • Block or disconnect lines from tanks before initiating welding operations. • Completely drain and thoroughly rinse tanks or lines prior to welding operations. • Ensure that equipment is completely dry from cleaning solvent residues. • Wear a respirator or provide effective, local exhaust ventilation during welding to prevent potential exposure to toxic fumes. • Assume good general ventilation of the work area. • Comply with all additional provincial workplace safety requirements.

NIOSH = National Institute for Occupational Safety and Health

* An initial workplace monitoring program will have determined the need for respirator use. The results of the program are assumed to be indicative of conditions in subsequent facility operations, unless procedural or design changes have occurred.

** Heavy-duty, lined polyvinyl chloride, vinyl-coated, neoprene, NBR, or rubber.

7 Design Recommendations

Tables 21 to 25 present good design features specifically applicable to ACZA wood preservation facilities. The recommendations made here must be used in conjunction with the basic design criteria listed in Part I, Chapter A - General Background Information and Recommendations: section 7. It should be noted that ammonia is highly corrosive to copper and zinc alloys; therefore pipes, valves, etc. should be made of non-corrosive materials.

Table 21 Recommended Design Features for Chemical Delivery Area

(See also Part I, Chapter A - General Background Information and Recommendations, Table 3.)

Delivery format	Design feature	Recommendations
Bulk liquid (aqua ammonia delivered by truck or rail tanker)	Emergency response	• Provide accessible storage for spill-response equipment, absorbent (lime) and personnel protection equipment. • Provide emergency ventilation for ammonia vapour control (in enclosed spaces).

Table 22 Recommended Design Features for Chemical Storage Areas

(See also Part I, Chapter A - General Background Information and Recommendations, Table 4.)

Storage format	Design feature	Recommendations
Bulk ACZA liquids • Aqua ammonia • Working solutions • Contaminated surface runoff • Drip return	Spill containment	• Provide water sprays and/or ventilation to control ammonia vapours.
	Drip containment	• Provide adequate ventilation to control ammonia vapours.
	Backflow prevention	• Install backflow preventers on all waterlines at plant entry. • Use top entry of waterlines to tanks (as secondary backflow protection). • Waterlines must comply with all applicable local codes.
	Emergency response	• Provide accessible storage for spill-response equipment, absorbents (sawdust for work solutions, drip return, runoff) and personnel protection equipment. • Provide for emergency ventilation in enclosed spaces.
Drummed solids • Copper oxide • Zinc oxide • Ammonium bicarbonate	Shelter/containment	• Provide a secure, enclosed paved area. • Store bags on pallets or in an area elevated from the floor.

Table 23 Recommended Design Features for Chemical Mixing Systems

(See also Part I, Chapter A - General Background Information and Recommendations, Table 5.)

Chemical form	Design feature	Recommendations
• Aqua ammonia • Working solutions • Drip return • Contaminated surface runoff	Location/shelter	• Locate mixing and working solution tanks in an enclosed, heated area, particularly if sub-freezing temperatures are encountered during operation.
	Spill prevention	• Interlock high-level alarms to tank feed pumps. • Provide equipment to enable safe, controlled manipulation of ingredient drums and bags. • Provide equipment for transferring drum and bag contents with minimum worker contact and minimum spill potential.
	Ventilation	• Provide an efficient scrubbing system for the mix tank to minimize emissions.

Table 24 Recommended Design Features for Treatment Process Systems

(See also Part I, Chapter A - General Background Information and Recommendations, Table 6.)

Design feature	Recommendations
Ventilation	• Provide adequate routine and emergency ventilation to control ammonia vapour levels in all work areas.
Process emissions to air	• Vent all air emissions (including tank vents and vacuum exhausts) to the building exterior. • Install control equipment as required to comply with applicable air emission limits for ammonia. • Install traps on otherwise uncontrolled vents (to remove entrained liquids).

Table 25 Recommended Design Features for Freshly Treated Wood Drip Areas

(See also Part I, Chapter A - General Background Information and Recommendations, Table 8.)

Design feature	Recommendation
Objective: To minimize losses of preservative chemicals from treated wood by: – providing proper conditions for preservative stabilization in freshly treated wood; – controlling the generation and disposal of contaminated runoff waters; – controlling the contamination of plant sites.	
Preservative stabilization*	• Provide for storage of all freshly treated wood in a specially designated area, with assured recovery of dripped material and precipitation. This area should be roofed to protect from precipitation but open to allow free air circulation (holding area). The holding time and size of the holding area must be sufficient to allow adequate stabilization of preservative chemicals (as determined by consideration of wood type, process parameters, operational practices and ambient conditions); the holding time must also be sufficient to allow for drippage to stop. See Table 29 to determine the size of the holding area.

*ACZA stabilization in the wood depends on ammonia loss, which, unless done under controlled conditions in a fixation facility, is primarily determined by climatic conditions (e.g. temperature, humidity, air exchange rates).

8 Operational Recommendations

The recommendations for good operating practices listed in Tables 26 to 29 must be used in conjunction with those in Part I, Chapter A - General Information and Recommendations, section 8. The objectives are meant to protect both workers and the environment from harmful exposure to ACZA components and solutions.

Table 26 Recommended Operating Practices for Chemical Handling and Storage

Operation	Recommendation
Storage of wood preservation chemicals	• Vent arsenic acid drums periodically as recommended (consult with suppliers).

Table 27 Recommended Operating Practices for Process System

Aspect	Recommendation
Post-treating checks	• Avoid exposure to ACZA or ammonia mists, aerosols or vapours. Do not breathe ACZA vapours.

Table 28 Recommended Practices for Maintenance, Cleanout and Shutdown of Treatment Systems

Operation	Recommendations
Equipment maintenance	• Drain and/or clean ACZA chemicals from equipment prior to maintenance. • Flush equipment thoroughly with water; recycle rinse waters to work solutions. • Thoroughly purge all ammonia vapours and provide effective ventilation.

Table 29 Recommended Practices for Post-Treating Procedures (27)

Operation	Recommendations
Treatment process	• After pressure treating, apply a final vacuum of max. 25 kPa for at least 2 hours. The retort should be heated to between 80 and 100ºC during the vacuum process. • After removal from the retort, keep the materials on the drip pad/holding area until all dripping has ceased.
Post-treatment process	• Process the treated material under one or a combination of the following procedures: – *Minimum plant holding time*: Products (with treating stickers in place for sawn and plywood products) should be held in a storage area with free air circulation for a minimum of 3 weeks at ambient temperatures equal to or exceeding 15ºC. If the ambient temperature is less than 15ºC, kiln drying or another source of artificial heat should be used to achieve the 15ºC. – *Post-treatment kiln drying* : Products should be kiln dried to a maximum oven-dry basis moisture content of 30% in the specified treated zone, employing a kiln cycle of 50 to 70ºC dry bulb temperature. – *In-retort ammonia removal plus plant holding time*: Plants equipped to follow this procedure will find it a highly effective method for ensuring fixation. After the final vacuum period with heat, the retort door should be opened and ambient air drawn through the treated wood charge from the door to the rear of the retort to a scrubber at a minimum rate of 7 m^3/minute, for a period of 3 hours. The treated wood product is then handled in the same manner as under "*minimum plant holding time*" described above, except the minimum holding time is 1 week at ambient temperatures of 15ºC or more, rather than 3 weeks. – *Note: Extended final vacuums (e.g. for 8 hrs.) are beneficial, when applied at a minimum temperature of 15°C. This can reduce the required holding time significantly.*

9 Process Emissions and Disposal

9.1 Control, Treatment and Disposal

Potential process emission sources at ACZA wood preservation facilities were described in section 5.2 and Figure 1. The main categories of process wastes or emissions that may be encountered at ACZA facilities and recommended disposal methods are presented in Table 30.

9.2 Liquids Containing ACZA

Liquid Process Wastes

Liquid process wastes (i.e. >1% total oxides) should not normally be discharged from ACZA plants. Liquid solutions, such as drips and washwaters, containing ACZA should be routinely collected and reused as makeup in preparing new treatment solutions. If unusual circumstances (such as prolonged plant shutdown) prevent on-site reuse, transport to another ACZA facility (for reuse) should be arranged. The chemical supplier may be able to suggest another facility using ACZA. Disposal should be considered only as a last alternative.

If disposal is unavoidable, specific approval must be obtained from the appropriate regulatory agency. If no suitable means of disposal is readily available, then the solutions should be sealed in leakproof metal containers (see Tables 3 and 4 to assure compatibility with metal used for containers), labelled and stored in a secure area.

Contaminated Storm Runoff

Contaminated storm runoff should be minimized. Various approaches can be used, including proper wood treatment process operation (i.e. assure solution quality, proper material placement on trams to enhance drainage, and appropriate treatment cycles and final vacuum); roofed areas for treated product storage; adequate fixation prior to storage in the open environment; and containment of storm runoff waters. In areas of high rainfall, complete containment may not be economically feasible. If the release of ACZA-contaminated runoff does occur, then guidance (and possibly specific approval) may have to be obtained from the appropriate environmental regulatory agency. Control specifications may depend on factors such as the concentration of contaminants, the volume and frequency of the discharges, and the sensitivity of the receiving environment. The discharge of ACZA-contaminated runoff into waters inhabited by fish is subject to the provisions of the *Federal Fisheries Act*, because ACZA is considered a deleterious substance in this case.

9.3 Solids with High ACZA Concentrations

For the purposes of this document, solids with "high ACZA concentrations" include sludges from sumps, tanks and cylinders, and disposable cartridge filters used to filter recycled waters. Recovery of the components (copper and arsenic) would be ideal, but this option is not available in Canada at this time. The preferred means of disposal for ACZA-contaminated sludges and cartridge filters is solidification and burial in an approved, secure (hydrogeologically isolated) chemical landfill. It is the responsibility of the waste generator to obtain and comply with approvals required by the jurisdiction in which the disposal site/facility is located.

Solids with high concentrations of ACZA should be drained and stored in leakproof containers while awaiting disposal. Highly contaminated solids should be stored in a specifically designed area that is curbed and lined with impermeable material. The area should be roofed to protect the wastes from precipitation. Any seepage or leachate generated at the site should be contained.

Incineration of ACZA-contaminated materials is not recommended because of formation of toxic combustion by-products.

9.4 Miscellaneous Solid Wastes

Miscellaneous solid wastes (e.g. cleaned, empty arsenic acid and copper oxide drums, cuttings from ACZA-treated lumber) from ACZA wood preservation plants may be disposed at designated sanitary landfills as approved by the provincial regulatory agency. The ingredient drums should be triple rinsed with water prior to disposal, and the rinse water should be used for the preparation of work solutions.

9.5 Air Emissions

Air emissions at ACZA facilities are normally localized; effects, if any, would be confined within the boundaries of the facilities. Air emissions from ACZA facilities may include:

- vapours from ammonia storage tank vents;
- vapours from ACZA mixing and storage tank vents;
- vapours from vacuum pump discharge;
- vapours from opening of retort cylinder doors;
- vapours from freshly treated charges;
- vapours from kiln-drying operations.

Monitoring of mists (14) in the vicinity of several ACA retort cylinder door openings has shown arsenic concentrations below published ACGIH TLVs (18). However, ammonia emissions in the vicinity of ACA retort cylinder door openings and in the vicinity of freshly treated wood have also been reported at concentrations above occupational health limits. For example, Todd and Timbie (14) measured air-borne ammonia concentrations of up to 250 ppm at localized areas of one ACA facility. These concentrations were much above occupational health limits of 35 ppm for a 15-minute exposure and 25 ppm for an 8-hour exposure. Concern about ammonia releases and controls at an ACA facility have also been expressed in an Environment Canada report (23). ACZA operations are likely similar to ACA operations, although no published data seem to exist at this time.

Table 30 Recommended Disposal Practices for Wastes Contaminated with ACZA

Wastes category	Examples	Recommendations
Liquid ACZA solutions	• ACZA concentrates • ACZA work solutions • Drips from freshly treated lumber • Washwaters	• Reuse as makeup for work solutions (standard practice at ACZA plants).
Contaminated solid wastes	• Debris and bottom sludge from storage tanks, cylinders and sumps • Debris and sludges from recycle filters • Any wood waste or wood debris that has contacted ACZA solution	• Drain, drum and dispose of in a secure chemical landfill with prior approval of the regulatory agency. • Do not burn ACZA-contaminated wastes (toxic gases may be formed).
Miscellaneous solid wastes	• Empty concentrate drums	• Rinse thoroughly and dispose of by returning drums to supplier or in designated sanitary landfills subject to approval by the regulatory agency.
	• Scraps, cuttings and shavings from ACZA-treated lumber • Solid fire residues	• Dispose of in sanitary landfills subject to approval by the provincial regulatory agency.
Contaminated storm runoff	• Any storm runoff or contaminated liquid discharge that contains arsenic at concentrations exceeding 0.5 mg/L, or whose discharge results in concentrations of arsenic in the receiving environment exceeding 0.05 mg/L, or whose discharge results in concentrations of copper or zinc in the receiving environment exceeding 0.005 mg/L.	• Prevent or minimize contamination of storm runoff. • Contain and reuse contaminated runoff as makeup for work solutions (to the greatest possible extent). • Monitor surface water discharges (in consultation with the provincial regulatory agency) to assess contaminant concentrations. *Note* : Discharge limits are subject to change. Verify current limits with authority having jurisdiction.
Firefighting water runoff	• As above (contaminated storm runoff)	• Contain and reuse contaminated runoff as makeup for work solutions (to the greatest possible extent). • If reuse is not practical, consult with the provincial regulatory agency to determine acceptable disposal.

10 Emission and Site Monitoring

Site monitoring and assessment are required at ACZA facilities, in accordance with the design and operating objectives described in this document, to verify that wood preservative chemicals are properly managed at the site and to ensure environmental and worker health protection.

Environmental monitoring requirements would normally be developed in consultation with provincial regulatory agencies and, where applicable, Environment Canada, whereas worker health monitoring programs may be developed in consultation with a provincial workers' compensation board and/or department of labour.

A program needs to ensure that adequate monitoring sites and frequencies are selected and that the preservative constituents, detection levels and quality control are defined. The appropriate components of a site and worker exposure monitoring program are contained in Part I, Chapter A - General Background Information and Recommendations, Tables 14 and 15.

11 Transportation of ACZA Components, Solutions and Wastes

The transportation of copper and arsenic drums, ammonia, ACZA solutions and ACZA wastes are regulated under the federal *Transportation of Dangerous Goods* (TDG*) Act*. The act does not apply to the transportation of treated wood or treated wood wastes. The regulation of intraprovincial movement of dangerous goods is a provincial responsibility.

12 Spill and Fire Contingency Planning

Preparedness for emergencies is essential in any wood preservation plant. Hence, facilities using ACZA should prepare and have readily available detailed contingency plans to ensure that response to spills and fires is quick, safe and effective.

12.1 Spill Contingency Planning

In addition to the recommendations in the corresponding section 12.1 of Part I, Chapter A - General Background Information and Recommendations, the following recommendations apply to ACZA facilities if a spill of ammonium hydroxide, ACZA solution or arsenic acid occurs:

- immediately put on appropriate full-face mask (ammonia canister for ammonia or ACZA spill, approved cartridge respirator for arsenic acid, e.g. TC21-C);
- always stay upwind to avoid potential exposure to ammonia fumes;
- for ammonia spill, use water spray to knock down vapours;
- if tanks other than normal work tanks are used for salvage purposes, assure compatibility of materials, i.e. do not use galvanized or aluminum tanks because of the corrosiveness of ammonia.

12.2 Fire Contingency Planning

Although the ingredients of ACZA and ACZA solutions are not flammable, precautions should be taken in the event that a fire occurs in the vicinity of ACZA solutions, arsenic acid or ammonia. Ammonia gas could be released if ACZA or aqua ammonia are heated. Mixtures of ammonia and air in an enclosed space with an ignition source could be explosive. In addition, heating of ACZA or drums containing arsenic could result in the formation of toxic arsenic vapours.

Using water blanket areas and water spray to suppress toxic dust and gases, and keeping temperatures of oxidizable materials below that for ignition, are additional items for the fire contingency plan recommended in section 12.2 of Part I, Chapter A - General Background Information and Recommendations.

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CHAPTER D

Creosote Wood Preservation Facilities

Preservative-specific Information and Recommendations

This chapter must be used in conjunction with Part I, Chapter A -
General Background Information and Recommendations.

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1 Production and Use

The American Wood Preservers' Association describes creosote, as used by the wood preservation industry, as "a distillate of coal-tar produced by high temperature carbonization of bituminous coal. Creosote consists principally of liquid and solid aromatic hydrocarbons and contains some tar acids and tar bases; it is heavier than water, and has a continuous boiling range beginning at about 200°C" (1).

During distillation of coal tar, the first fractions contain the light oils (or low molecular weight oils), with pitch being the main product. The higher boiling point liquid fraction recovered between the light oils and pitch is designated creosote. The character of the tar, details of the distillation process, and proportion of distillate included in the creosote fraction, all influence the chemical and physical characteristics of the creosote. Therefore, relative concentrations of creosote components can vary from batch to batch.

Creosote has been known for its preservative properties since 1706. In 1838, the Bethell (full cell) process using creosote was patented. Creosote is still used principally for wood preservation. In addition, it is also used as a fuel in foundries, as pitch for roofing, as an animal dip, and as a lubricant for die moulds. Creosote has been described as one of the most effective substances known for the protection of wood against all forms of wood-destroying organisms (2). It has a marked toxicity to a wide spectrum of wood-destroying fungi, marine borers and insects.

Creosote's attributes, aside from its broad spectrum efficacy, are that it gives the treated wood water repellency, improved dimensional stability and mechanical wear, corrosion resistance, reduced electrical conductivity and increased resistance to corrosive chemicals.

Creosote for wood preservation uses is currently produced in Canada and imported from the United States. It is used primarily for treatment of railroad ties, where it is blended 50:50 with a heavy oil or used at full strength for poles, marine pilings and timber, and other construction timbers. Table 1 provides an overview of creosote usage in Canadian pressure treatment facilities.

Table 1 Overview of Creosote Usage in Canada

Feature	Characteristics
Delivery format	Bulk, rail, truck, ship
Chemical family	A distillate of coal tar, whose major components include naphthalene, phenanthrene and fluoranthene
Suppliers to Canadian facilities (1996)	• Koppers Industries Inc., Pittsburgh, PA • VFT Inc., Hamilton, ON
Estimated use quantity (1992) - Canadian pressure treaters	• 23 200 t (4)
Concentration of work solutions	Either 100% creosote or 50:50 mixture of creosote and petroleum oil
Typical preservative retention in treated wood	96-290 kg creosote/m^3 treated wood (6-18 lbs./ft.^{3}); typically 128 kg/ m^3 of wood
Major products treated in Canada	Railroad ties, marine pilings and timber, construction timbers

2 Physical and Chemical Properties

Creosote contains hundreds of individual components. Polycyclic aromatic hydrocarbons (PAHs) are the main constituents of creosote. Other components include tar acids (e.g. phenols, cresols and cresylic acid) and tar bases (e.g. pyridines, quinolines and acridines) (3).

The many components in creosote complement each other in effecting wood preservation. The lighter molecular weight PAHs in creosote are generally more toxic to decay organisms. The heavier molecular weight components of creosote help “retain” the more toxic lighter components within the wood by minimizing leaching or volatilization. The heavier residues of creosote, when impregnated into wood, also act as water repellents, limiting moisture changes and subsequently minimizing splitting of wood (2).

Because of the many components of creosote and their varying concentrations, the physical and chemical properties of creosote per se can only be generalized. Table 2 summarizes properties that have been compiled in various documents (5, 6, 7, 8).

Properties that warrant special consideration for the safe handling of creosote include its:

- combustibility;
- moderate vapour pressure;
- solubility of certain fractions in water;
- density, which is greater than water, implying that creosote will sink to the bottom of fresh and marine waters.

Table 2 Physical and Chemical Properties of Creosote

Identification		
Common synonyms: (past and present) Creosote oil Coal tar creosote Cresotum, Naphthalene oil CAS Registry Number: 80001-58-9	Manufacturers: • VFT Inc., Hamilton, ON • Koppers Industries Inc., Pittsburgh, PA	
Transportation and storage information		
Shipping sate: Liquid **Chemical family:** Coal tar distillate **Classification:** Combustible **Storage temperature:** Ambient	**Inert atmosphere:** No requirement **Venting:** Open (flame arrestor), or to filter systems **Containers/materials** Tankers, tank cars, tank trucks (steel)	**Labels:** Red and white **Class:** Check with Transport Canada
Physical and Chemical Properties		
Physical state: Liquid/solid mixture at ambient temperatures. **Solubility** Practically insoluble in water. Soluble in alcohol, benzene and toluene. **Floatability:** Sinks in fresh and marine waters.	**Specific gravity** 1.05-1.09 at 15°C **Vapour pressure:** Variable **Boiling point:** 200-450°C **Odour:** acrid, tarry aromatic **Vapour density:** Variable (typically 3 to 5)	**Appearance:** Yellow to black, oily liquid with sharp, aromatic or tarry odour **Melting point:** Varies (-60 to -20°C) **Flash point** >74°C (combustible liquid) **Explosive limits:** Variable, 1% to 7%
Hazard data		
Fire: *Extinguishing data*: Use dry chemical, foam or carbon dioxide. Use water to cool fire-exposed containers. *Fire behaviour*: Forms irritating heavy black smoke. *Ignition temperature*: Variable, typically 400°C. *Burning rate*: 4 mm/min.	**Reactivity:** *With water:* No reaction; insoluble. *With common materials* : May react with oxidizing agents or strong acids. *Stability*: Stable	

3 Environmental Effects

3.1 Distribution in the Natural Environment

A comprehensive perspective on sources and distribution of PAHs in the Great Lakes is provided in the 1983 report of the International Joint Commission's Aquatic Ecosystem Objectives Committee (9). The report indicates that the major anthropogenic sources of PAHs in the environment are fuel combustion (coal, oil and wood burning), refuse combustion and coke production. Fossil fuels such as crude or bunker oil contain PAHs, and accidental spills from boating and shipping activities contribute considerably to PAH contamination in coastal waters. Levels of PAHs in waters, air and sediments in the vicinity of populated and industrial areas are frequently significantly higher than in non-populated areas.

Since PAHs are also produced during forest fires and volcanic eruptions (9), they can be considered natural compounds. It has been estimated that forest fires contributed 10% of total PAH emissions in the United States during the mid-1970s (10). To illustrate PAH levels in the environment, Table 3 lists concentrations found in sediments, water and biota of the Great Lakes. The sediment data show the influence of anthropogenic sources on PAH levels in the environment (e.g. Lake Superior versus Lake Erie).

Releases from creosote wood preservation facilities have been reported and are primarily ascribed to historical events resulting from poor operating practices. Contamination of several Canadian preservation plant sites has been reported (40). The available evidence, which is limited and not very conclusive, indicates that the quantities of PAHs entering the environment from treated wood in service are small (11).

Table 3 Examples of PAH Concentrations in the Great Lakes Ecosystems (9)

PAH	Lake Superior	Lake Erie	Lake Ontario
		Sediments (µg/kg)	
Phenanthrene	0.034	0.346 ± 0.092	0.0585
Benzo(a)pyrene	0.028	0.255 ± 0.152	0.076 – 0.306
		Fish (µg/kg)	
Benzo(a)pyrene		0.046 ± 0.041 (Detroit River)	0.069 ± 0.044
		Herring gull lipid (µg/kg)	
Phenanthrene			0.002
Benzo(a)pyrene			0.030 – 0.038
		Water (µg/L)	
Phenanthrene		Mean for Great Lakes water system: 0.024	
Benzo(a)pyrene		Mean for Great Lakes water system: 0.012	

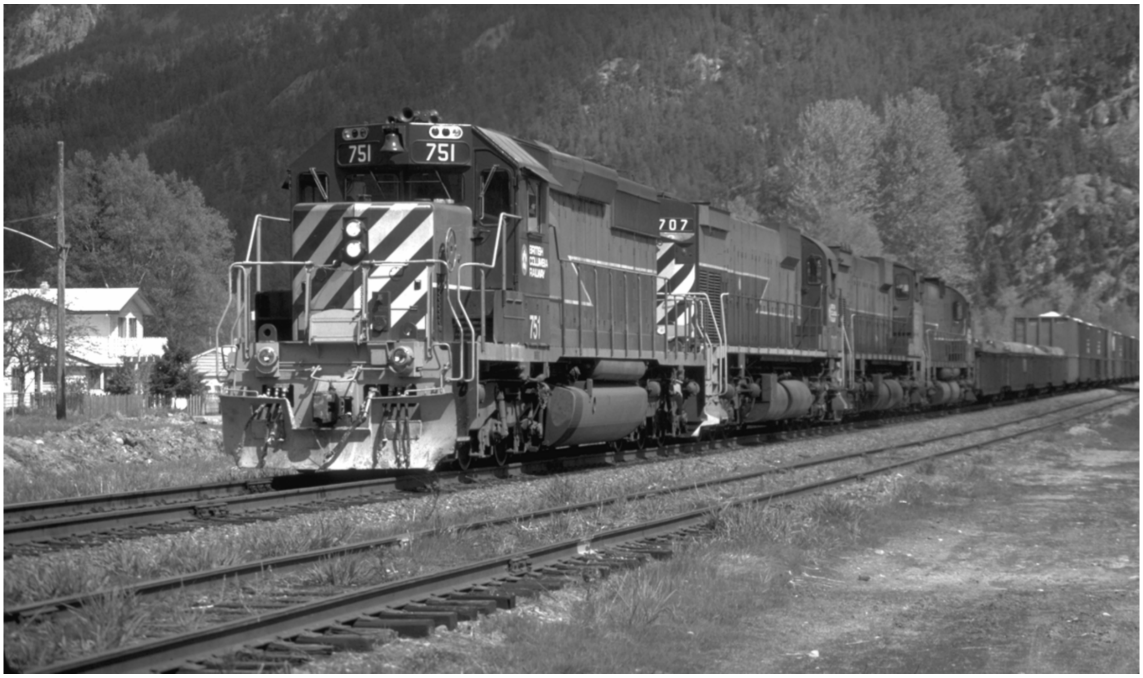
3.2 Environmental Criteria

Although there are no water quality objectives or standards specifically for creosote, water quality criteria do exist for component compounds or indicators of creosote (9, 12, 13, 14). These criteria are summarized in Table 4. However, the Canadian Council of Resource and Environment Ministers' Canadian Water Quality Guidelines state that "there is insufficient information to recommend guidelines for polycyclic aromatic hydrocarbons" (15).

Table 4 Regulatory Limitations for Creosote or Components of Creosote in Natural Waterbodies

Limit type	Limit value	Basis	Agency
Objective	0.01 µg/L benzo(a)pyrene* in water	Protection of fish and other aquatic organisms from carcinogenic or tumorigenic effects	International Joint Commission (9)
	1.0 µg/L benzo(a)pyrene in sediments or in organisms serving as food sources for fish	Protection of fish	
Guideline	0.01 µg/L benzo(a)pyrene in water	To protect drinking water	CCME (16)
Maximum acceptable concentration	2 µg/L phenols	To protect drinking water (aesthetic considerations)	Health and Welfare Canada (12)
Objective	0.05 of 96-h LC_{50} for unspecified, non-persistent toxic substances	To protect aquatic organisms	International Joint Commission (14)

* Benzo(a)pyrene was selected because limitations on benzo(a)pyrene were considered effective in limiting other PAHs.



4 Human Health Concerns

A safety objective for industrial use of any chemical, including creosote, is to minimize worker exposure. If safeguards are not provided or not implemented, a variety of human health effects can occur, depending on the duration and manner of exposure; concentration of the chemical to which exposure has occurred; and the varying metabolic sensitivities of individual workers. On the basis of information from existing literature, Table 5 outlines the spectrum of human health effects that could result from various degrees of exposure to creosote.

4.1 Special Sensitivity

Natural sensitivity to creosote exposure, particularly skin sensitivity, varies widely (21). As a result, National Institute for Occupational Safety and Health (NIOSH) has suggested the need for pre-employment and regular medical surveillance of workers (21). Prior to employment, workers should be informed of any sensitivities. The information should be used not to bar workers from employment but to assure that proper precautions are applied.

Table 5 Effects of Creosote on Human Health

Exposure	Degree of exposure*	Documented health effects
Inhalation	• Brief inhalation of vapours in excess of TLV • Repeated or prolonged inhalation of mists or of vapours in excess of TLV	• Irritation of nose and throat (19). • Sweating, thirst, nausea, vomiting, stomach pain, with subsequent convulsions or coma (22).
Eyes	• Repeated or prolonged exposure to mist or vapours . • Direct contact with liquid (i.e. splattering).	• Irritation. • Severe burns (21).
Skin	• Occasional direct contact with liquid, vapours, or mists.	• Reddening and itching (contact dermatitis) (19, 22). • Effects enhanced by exposure to sunlight (19, 20). • Burning may result if creosote is not removed from skin (18).
	• Extensive exposure (i.e. total immersion of worker in tank, improper protective measures inside storage tank or retort).	• Absorption of creosote through skin causes discoloration of skin, sweating, thirst, vomiting, diarrhea and stomach pains (21, 22).
	• Heavy regular contact over long period of time.	• Potential for skin cancer has been reported (17, 21).
Ingestion	• One-time ingestion.	• Burns mouth, throat and stomach (22). • Subsequent salivation, vomiting, respiratory difficulties, thready pulse, vertigo, headache, loss of pupillary reflexes, hypothermia, cyanosis and convulsions (22). • Fatal dose: 7-10 g (19, 22) 30-50 g**(23). • Death would be due to circulatory collapse and respiratory failure (19).

TLV = threshold limit value.

* Workers may have varying sensitivities to exposure.
** Calculated from animal feeding studies.

5 Description of Preservative Application and Potential Chemical Discharges at Creosote Wood Preservation Facilities

In 1993, there were six active pressure wood preservation facilities in Canada applying 23,200 t of creosote to 0.19 million m^3 (6.7 million $ft.^3$) of wood (4). With the exception of one plant, all have been in operation for 50 years or more. A highly individualized approach exists to design and operating practices, which is emphasized by the fact that the technical support services at those facilities depend upon internal resources. These older plants, although state of the art at the time of construction, had no benefit of today's knowledge of environmental protection. However, the plants have used the recommendations contained in the previous technical recommendations documents to upgrade designs and operating practices with the goal of meeting current regulatory requirements (24).

5.1 Description of Process

Creosote is used either in a mixture of 50:50 creosote/petroleum oil or alone (full strength). Creosote and petroleum oil are delivered to wood preservation facilities by bulk truck or rail tanker and are stored in a bulk storage tank. After delivery of the creosote and petroleum oil, the following process steps occur (see Figure 1):

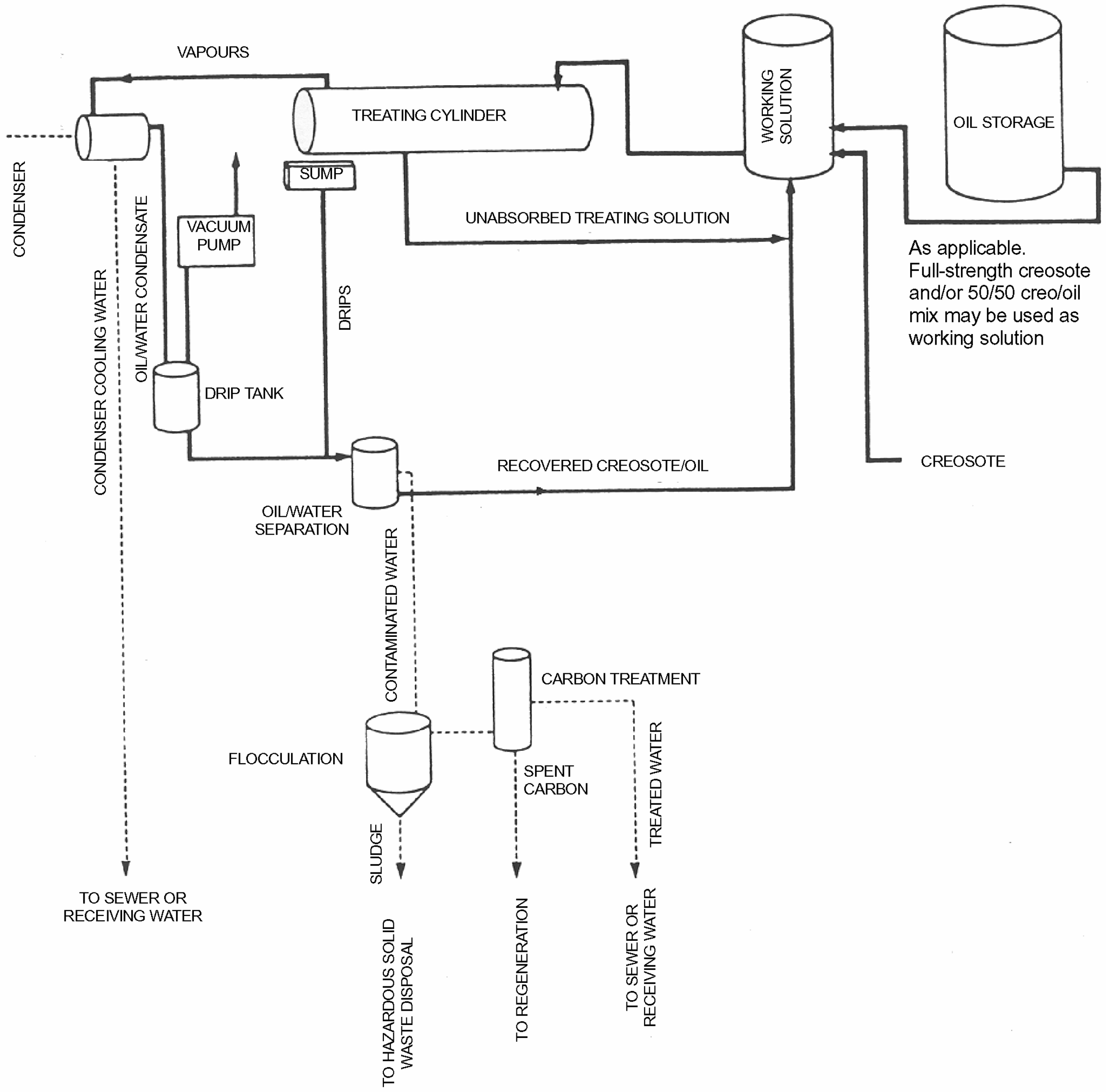
Chemical Mixing

In Canada, creosote/petroleum oil mixtures are blended by pumping transfers and recirculation between bulk tanks. The benefits of blending creosote with oil are lower cost and improved penetration (lower viscosity) in applications such as railway ties, where conditions of use allow for less protection than that usually provided by 100% creosote. The physical properties of wood treated with a mix are quite similar to those of material treated with 100% creosote, for example, better dimensional stability (compared with untreated or water-borne treated wood), improved mechanical wear, corrosion inhibition, resistance to chemicals, water repellency and improved resistance to electrical conductivity. Full strength creosote is used where maximum biocidal protection is desired, such as for timbers exposed to marine borers.

Wood Conditioning

In order to enhance penetration of the water-immiscible creosote into the wood, the moisture content of the wood is reduced by a conditioning process. Conditioning may be achieved by air seasoning, kiln drying or by processes carried out in the treatment cylinder, for example, application of steam and subsequent vacuum, or boiling under a vacuum in the presence of the treating solution (Boultonizing). Boultonizing is a common means of conditioning in Canada. For given wood products, conditioning procedures are stipulated by the Canadian Standards Association (25).

Figure 1 Process Flow Diagram of a Creosote Pressure Treatment Plant



As applicable.
Full-strength creosote and/or 50/50 creo/oil mix may be used as working solution

Preservative Application

If Boultonizing or steam-vacuum processes have been used for conditioning, creosote is applied in the following steps either by the full-cell treatment process or the empty-cell treatment process. It should be noted that in contrast to treatments with water-borne preservatives, creosote solutions are applied at an elevated temperature (70°C - 90°C).

Depending on the species of wood, the wood product and the moisture content of the wood, the operator of the facility determines the appropriate treatment process (full cell or empty cell), and the pressure, temperature and times for various process sequences.

Many of the operating parameters, preservative standards and product quality criteria (e.g. degree of preservative penetration and retention) are defined by the Canadian Standards Association (25).

An expansion bath and final vacuum are usually added after the pressure cycle to render product surfaces relatively dry and to minimize long-term "bleeding" of preservative. The treated wood is withdrawn from the treating cylinder and stored on a drip pad until drippage has essentially stopped. From there the wood is either taken for storage in the yard or shipped by truck or rail car. Best management practices are promoted by the industry association (CITW), to minimize preservative drippage and bleeding during storage and service (27).

5.2 Potential Chemical Discharges

Creosote wood preservation facility design and operational practices vary (24, 26), and each facility has potential sources of emissions that could affect worker health and/or the environment. The potential sources and releases are illustrated in Figure 2.

Liquid Discharges

Leaks and drips of oil solutions can be contained and reused in the oil-borne treatment process. Liquids that cannot be recycled and reused may include:

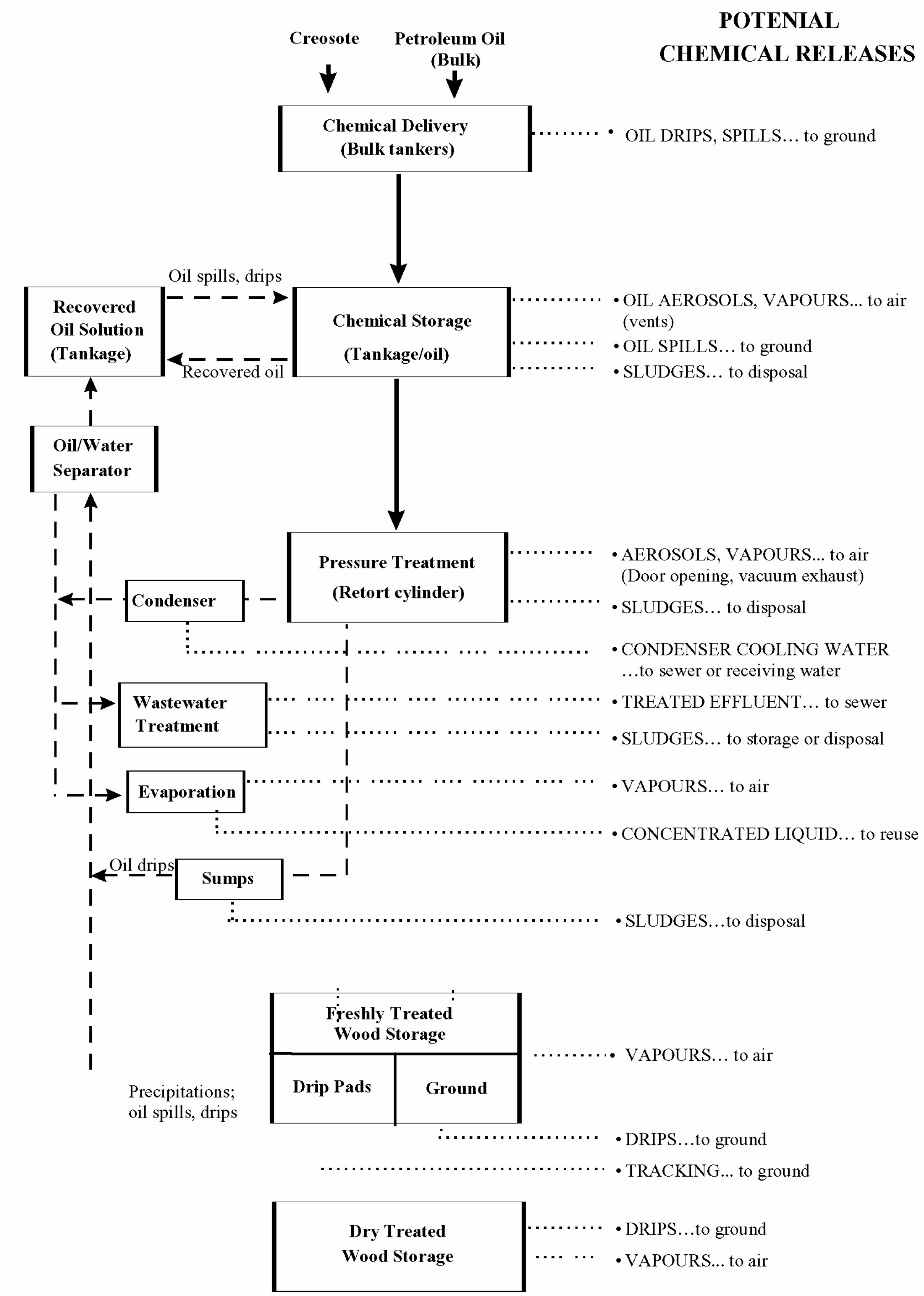
- condensates removed from wood during the conditioning and during the initial application of vacuum;
- water released by the wood during the treating cycle and subsequently separated from the unabsorbed treatment oil prior to recycling of the oil;
- washwaters.

These liquids can contain creosote and must be treated before discharge as a waste stream.

Other liquids that may be released from oil-borne creosote facilities include the following:

- steam condensates from indirect heat transfer in cooling and heating coils, which are generally checked for contamination prior to discharge;
- condenser cooling water, which is not normally contaminated and is discharged without treatment;
- surface runoff from treated wood storage areas contaminated by preservative.

Figure 2 Potential Chemical Releases from Creosote Pressure Treatment Plants



The creosote content in runoff waters depends on many factors, including vacuum and drip time in the last step of the pressure process; viscosity of the wood preservative; wood species; moisture content of the wood prior to application of preservative; specific treatment process (i.e. full cell versus empty cell); and exposure to the weather. The need for control of runoff waters would depend upon analytical and/or bioassay evaluations and regulatory requirements.

Solid Wastes

Solid wastes from creosote treatment facilities include:

- sludge from tanks, sumps and pressure cylinders;
- sludges from wastewater treatment processes (e.g. flocculated material);
- contaminated soils.

Air Emissions

Air emissions from creosote treatment facilities are generally localized and may include:

- emissions during application of vacuum for wood conditioning, for the full-cell process or during the final vacuum step;
- vapours from tank vents;
- vapours from treating cylinders;
- vapours from opening of cylinder doors;
- vapours from freshly treated charges.

5.3 Potential Effects

The actual impact of any chemical released to the environment depends on many factors, including the location of the wood preservation facility relative to ground or surface waters, the species of aquatic biota in adjacent surface waters, and the amount of preservative released. Variables that can influence effects on worker health include ambient concentrations, frequency of exposure and protective measures during the time(s) of exposure.

All creosote-using facilities could affect the environment, as could any chemical-using industrial facility, if proper control measures are not in place. Documented releases of creosote from wood preservation facilities have been due either to poor design or to poor operating practices. The effects of these releases appear to be localized at the plant site (i.e. soil and groundwater contamination) or in the immediate environment adjacent to the plant site (41).

Human health could be affected if appropriate precautions are not taken during spills of creosote and residues, operation of the treatment system (e.g. cylinder door opening) and handling of treated products. Skin burns and allergic reactions were reported in a survey of the accident history of 50 pressure treatment plants (28). A review of the literature by Todd and Timbie (20) concluded that “there is neither positive nor negative human experience data in the wood treating industry to indicate that additional or less restrictive exposure control is appropriate.”

6 Personnel Protection

6.1 First Aid

The general rule applies: for work with creosote, creosote/oil mixtures and/or sludges, there is a need for protective measures and immediate response if contact occurs. Table 6 contains the recommended actions in case of creosote exposure.

Table 6 First Aid for Creosote Exposure*

Exposure	First action	Second action
Eye contact	• Immediately flush eyes with flowing water, occasionally lifting the upper and lower lids. • Flush eyes for at least 15 minutes.	• Get medical attention.
Skin contact	• Immediately remove soaked clothing or articles in contact with the skin. • Immediately wash contaminated skin thoroughly with soap or mild detergent and water.	• Get prompt medical attention if the skin becomes inflamed (redness, itchiness or pain).
Inhalation	• Immediately move the affected person to fresh air.	• Resuscitate affected person if required. Open the airway. Shake and shout. • Mouth-to-mouth protection is recommended. If no pulse, apply CPR. • Keep affected person warm and quiet. • Get medical attention.
Ingestion**	• Do not induce vomiting. (42) • Give conscious victim water or milk to drink.	• Call a physician immediately. Then give 30-60 mL of Fleet's Phospho-Soda diluted 1:4 in water.
Chronic symptoms requiring medical referral	• Skin irritation, sensitivity. • Skin lesions.	

* Potential exposure to creosote in pressure treating facilities includes exposure to creosote, creosote treating solutions and sludges, contaminated aqueous solutions and treated wood. Inhalation exposure can occur from vapours or aerosols.

** Regularly consult with competent medical advisors for updated recommended first and second actions.

6.2 Regulatory Controls

Most regulatory criteria established by worker protection agencies are based on threshold limit values (TLVs) and biological exposure indices, as recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). Creosote per se is not addressed by the ACGIH. The ACGIH suggests the use of benzene soluble fractions of coal tar pitch volatiles as a measure of exposure (18). Table 7 reviews the ACGIH-recommended limits and provides recommendations designed to define acceptable levels of worker exposure to creosote in the wood preservation workplace.

The ACGIH recommended threshold limit value - time weighted average (TLV-TWA) for creosote represents a TWA concentration "for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect." The recommended TLV-TWA value for benzene-soluble fractions of coal tar pitch volatiles is 0.2 mg/m^3. Recently, the ACGIH has suggested augmentation of TLV workplace evaluations by use of "biological exposure indices (which) may be useful as a guide to safe exposure" (18).

Table 7 Levels of Concern for Creosote Exposure in the Workplace

Route of entry	Basis for recommendation	Recommendations/comments
Skin and eye contact	Creosote is a skin irritant and a potential skin carcinogen.	• Use protective measures for workers in contact with creosote (Table 8). • Avoid direct contact of skin and eyes with creosote solutions or sludges. • Use barrier creams for exposed skin areas. • Sensitive individuals should take special care to avoid exposure. • Current material safety data sheets should always be readily available to workers.
Inhalation	ACGIH threshold limit value 8-hour time weighted averages (TLV-TWA): Benzene-soluble coal tar pitch Volatiles: 0.2 mg/m^3 air (Potential contributions to overall exposure can occur through the cutaneous route, including mucous membranes and eye, either by airborne or, more particularly, by direct contact with the substance.)	• Ensure good ventilation and protective measures as suggested in Table 8. • Use self-contained breathing apparatus for firefighting activities where creosote is present. • The permissible concentration of creosote refers to vapours and aerosols.
Ingestion	The reported lethal dose of creosote for adults ranges from 7 g (5) to 50 g (19, 22, 30).	• Prevent the ingestion of any quantity of creosote.

The ACGIH TLV-TWAs for chemicals are defined with the following provisos:

- “The limits are intended for use in the practice of industrial hygiene as guidelines for good practices or recommendations in the control of potential health hazards and for no other use” (i.e. proof or disproof of the cause of an existing disease or physical condition).
- “The limits are not fine lines between safe and dangerous concentration.”
- “In spite of the fact that serious injury is not believed likely as a result of exposure to the Threshold Limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical.”
- “When two or more hazardous substances, which act upon the same organ system, are present, their combined effect, rather than that of either individually, should be given primary consideration.”

Skin and Eye Contact

A wide range of dermal exposures to creosote can potentially be encountered in the workplace, from exposure to “pure” creosote, to creosote/oil mixtures or to waters containing a few parts per million creosote. A minimal level of protection and hygiene, for example, impermeable gloves and regular clothing changes, should be maintained by all facility workers who could have dermal exposure to creosote, creosote/oil and aqueous solutions of creosote or freshly treated wood. The level of protection should increase with increasing potential for exposure.

Inhalation

The ACGIH TLV-TWA values for coal tar pitch volatiles discussed previously are applicable as maximum allowable values for inhalation. Adequate design and operational procedures (e.g. adequate local ventilation and use of respiratory equipment, where necessary) will minimize worker exposure to vapours. Other potential sources of inhaled coal tar pitch volatiles include vapours in the vicinity of charge removal areas and in the vicinity of freshly treated wood, and aerosols at improperly maintained facilities (e.g. from leaking seals) or at inadequately designed facilities (e.g. from vacuum pump discharges to work area).

Ingestion

Oral intake of creosote must be avoided. Ingestion of creosote or creosote-containing liquids is unlikely if workers follow elementary rules of good hygiene. Acceptable limits of ingestion are not prescribed by regulation since there is no valid reason for any such intake to occur. The single dose level of creosote suggested to be fatal is in the order of 0.1 g creosote per 1 kg of body weight (19).

6.3 Safety Precautions

Table 8 Safety Precautions for Personnel Working with Creosote Solutions

Objective: To ensure safe workplace practices for each activity during the treatment process.	
Activity	**Recommendations**
Unloading or handling creosote	• Wear protective apparel, including goggles or face shields, impermeable gauntlets, coveralls, impermeable aprons and impermeable shoes or boots. (Resistance rating of materials: excellent — viton, neoprene, butyl rubber; good — nitrile, polyvinyl chloride (PVC); fair — polyvinyl alcohol, polyethylene.) • Do not wear contact lenses. • Work in well-ventilated areas. • Approved respirators should be readily available. Wear respirators in accordance with NIOSH guidelines whenever airborne contaminant concentrations are unknown or in excess of TLVs. • Provide an emergency eyewash and shower in the immediate unloading or handling areas. • Provide adequate equipment for safe, controlled transfer of creosote as outlined in section 4 of the National Fire Code of Canada and as appropriate for the specific facility. • Immediately clean creosote spills. • Thoroughly clean protective equipment after use.
Sampling procedures	• Wear eye protection and gloves impermeable to creosote when sampling creosote solutions, e.g. from a pipe tap. Other non-routine sampling efforts such as through cover ports may necessitate more stringent precautions. • Wear impermeable gloves when taking borings from freshly treated wood. • Clean gloves and goggles as soon as possible after completing sampling. • Clean the outside of sample containers after sampling solutions. • Wash hands thoroughly after all sampling operations.
Cleaning cylinders or storage tanks	• Follow all standard precautions for vessel entry (as per provincial health and safety regulations). • Flush vessels as required to establish safe entry conditions, or use an approved self-contained breathing apparatus prior to entry. • Wear NIOSH-approved respirators (or breathing apparatus as above) and creosote-impermeable gauntlets, outer clothing and boots during all vessel entries. • Provide self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode. • Provide combination respirator that includes Type C-supplied air respirator and full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode. • Always have a standby attendant present and provision for continuous outside communications. • Collect and store contaminated waste material in sealed and labelled drums. • Wash all protective equipment immediately after use. • Shower after cleaning retorts or tanks.

Table 8 Safety Precautions for Personnel Working with Creosote Solutions (continued)

Activity	Recommendations
Removing treated charges from cylinders	• Wear eye protection and creosote-impermeable gauntlets and coveralls or apron during door openings and when moving loads of freshly treated wood. • Avoid breathing preservative mists. Wear an approved respirator if airborne concentrations are unknown or at or above TLVs *.
Handling treated lumber	• Wear impermeable** gloves, apron and boots if handling treated wood manually. • Wear a respirator if treated wood is handled in enclosed areas (e.g. boxcars). • Change coveralls daily.
Handling and maintaining contaminated equipment	• Thoroughly steam-clean or flush contaminated equipment with solvent (e.g. Varsol or equivalent) prior to handling. (Contain all solvent washings.) • Change coveralls daily. • Wear impermeable apron, gloves and boots.
Welding	• Welding can produce toxic fumes. In addition to the precautions for handling and maintaining contaminated equipment: • Obtain the specific approval of the plant supervisor before welding. • Block or disconnect lines from tanks before initiating welding operations. • Completely drain and thoroughly rinse tanks or lines prior to welding operations. • Ensure that equipment is completely dry after cleaning solvent residues. • Wear a respirator or provide effective, local exhaust ventilation during welding to prevent potential exposure to toxic fumes. • Assure good general ventilation of the work area. Ensure that creosote volatiles have been purged from enclosures (tanks, cylinders) prior to welding. • Comply with all additional provincial workplace safety rules. • Prevent distribution of sparks to other contaminated areas or to areas where volatiles of creosote may be deposited.

* An initial workplace monitoring program will have determined the need for respirator use. The results of the program are assumed to be indicative of conditions in subsequent facility operations, unless procedural or design changes have occurred.

** As described under “Unloading or handling creosote.”

Note: Observe also the general precautions and personal hygiene measures outlined in Part I, Chapter A - General Background Information and Recommendations.

7 Design Recommendations

Tables 9 to 12 present good design features specifically applicable to creosote wood preservation facilities. The recommendations made here must be used in conjunction with the basic design criteria listed in Part I, Chapter A - General Background Information and Recommendations, section 7.

Table 9 Recommended Design Features for Chemical Delivery Areas

(See also Part I, Chapter A - General Background Information and Recommendations, Table 3.)

Delivery format	Design feature	Recommendations
Bulk liquid • Creosote • Petroleum oil (delivered by truck, ship or rail tanker)	**Objective:** To provide an off-loading area that enhances spill prevention and containment and complies with section 4 of the NFCC.	
	Off-loading pad	• Provide a loading site with impervious floor and curbs with provision to divert spills to a containment area in accordance with the NFCC.
	Drip control	• Design, install and maintain system to prevent leakage and spillage as per the NFCC.
	Delivery system piping	• Install piping and piping systems in accordance with specifications outlined in the NFCC, i.e. materials, corrosion protection, identification, joints, location and arrangement of pipes, valves, heating, methods of transfer and operating procedures. • Install permanent delivery systems with rigid and accessible delivery lines (lines should not be buried). Shielded, flexible hoses may be required for connections to railcars and trucks. • Protect delivery systems if there is potential for vehicular impact or physical damage.
	Backflow prevention	• Install backflow preventers on delivery lines.
	Static protection	• Install acceptable provisions for electric bonding as per the NFCC.

NFCC = National Fire Code of Canada.

Table 10 Recommended Design for Chemical Storage Area

(See also Part I, Chapter A - General Background Information and Recommendations, Table 3.)

Storage format	Design feature	Recommendations
Bulk liquids • Creosote • Petroleum oil • Creosote/ petroleum oil working solutions • Contaminated surface runoff • Drip return	**Objectives:** ◊ To provide positive spill prevention features. ◊ To conform to the NFCC, where applicable.	
	Tanks	• Engineer construction materials and dimensions in accordance with ASME, CAN and API standards as defined in the NFCC. • Mount tanks on containment pad surfaces within a dyked area. • Locate tanks in accordance with the NFCC (i.e. minimum distances from buildings and other tanks). • Evaluate means of controlling contaminated surface waters (e.g. roofing of tanks, runoff water treatment). • Test for leakage prior to backfilling. • Vent interior tanks to the exterior or to collection point (never vent to the workplace); protect vents against release of entrained liquids or overflow (e.g. provide direct overflow piping to sumps or containment areas). • Provide grounding for tanks as per the NFCC. • Provide vent piping for vapour control as per the NFCC. • Subsurface tanks must not be used.
	Spill containment	• Provide structurally sound and impermeable dykes as per the NFCC. • Provide a dyked containment volume equivalent to 100% of a storage tank plus 10% of the aggregate volume of the remaining tanks, or equivalent to 110% containing wall for single tanks in isolated containment. • Engineer containment for long-term integrity (leak-proof for infiltration and exfiltration).
	Piping and valves	• Design according to applicable codes (e.g. NFCC). • Maximize the use of above-floor piping and/or open containment channels for subgrade piping (buried piping must not be used). • Provide freezing protection for piping (as appropriate and as per the NFCC if heat is applied).
	Spill prevention/detection	• Install devices to prevent overflow from tanks as per the NFCC, preferably reliable, independent high-level alarms on tanks (i.e. audible alarm). • At sites with inadequate containment areas (e.g. in terms of volume, lack of pavement) provide 24-hour monitoring alarms (with remote) for immediate detection of tank or pipe rupture. • Install means of emergency communications (e.g. telephone, walkie-talkie, etc.) manual alarm buttons (call for help) at potential major spill points.
	Location	• The preferred location for oil tankage (all solutions) is in an exterior centralized tank farm area, which is arranged in accordance with the NFCC.
	Security	• Provide security precautions to prevent vandalism or access to tanks by unauthorized persons (the NFCC requires a firmly enclosed fence surrounding bulk storage tanks if their aggregate capacity exceeds 564 000 L).

NFCC = National Fire Code of Canada.

Table 11 Recommended Design Features for Freshly Treated Wood

(See also Part I, Chapter A - General Background Information and Recommendations, Table 8.)

Design feature	Recommendations
Objective*: ◊ To minimize losses of preservative chemicals from treated wood by: – providing proper conditions for containing drips from freshly treated wood, and – controlling the generation and disposal of contaminated runoff waters.	
General design	• Integrate design provisions for: – efficient drip and runoff collection and containment (runoff can also be minimized by sheltering), – surface drainage and return of fluids to process with minimum dispersal from tracking by personnel and vehicles.
Drip time **	• Provide for sufficient storage area to hold all freshly treated wood until dripping is complete.
Containment	• Immediate drip areas should: – be impermeable (i.e. of concrete or other surfaces resistant to attack by oils), – be curbed, – have provision for collecting and storing all runoff and infiltrating precipitation (for treatment and controlled discharge under terms of existing regulatory standards). Where storage of runoff waters would be difficult, roofing should be considered.

* A facility should operate so that after-bleeding is minimal (e.g. good conditioning, expansion bath, final vacuum).

** The nature and magnitude of drippage losses depend strongly on oil and wood types and on process-specific factors.

Table 12 Recommended Design Features for Treated Wood Storage

(See also Part I, Chapter A - General Background Information and Recommendations, Table 9.)

Design feature	Recommendations
Objective: To minimize and control releases of contaminated surface waters from treated wood storage areas.	
Storage areas	• Evaluate options for storage area surfaces on the basis of factors such as groundwater usage, stormwater runoff, probability of bleeding and expected levels of precipitation. (Large paved areas will result in large quantities of runoff waters, but paved areas may be necessary if groundwater is consumed domestically in the area and/or if a high probability of preservative bleeding from the wood exists). • Locate unsurfaced ground storage areas away from surface waterbodies. • Routinely monitor contaminant levels in storage area runoff. Contaminant levels of concern to regulatory agencies may require collection and treatment of storm runoff waters.

8 Operational Recommendations

The recommendations for good operating practice listed in Tables 13 to 17 must be used in conjunction with those in Part I, Chapter A - General Background Information and Recommendations, section 8. They are meant to protect both workers and the environment from harmful exposure to creosote solutions.

Table 13 Recommended General Practices for Operating Creosote Treatment Facilities

Operation	Recommendation
Firefighting	• Establish a fire contingency plan (section 12.2) as required by the National Fire Code of Canada, and undertake all necessary action to maintain a state of readiness to implement the plan in case of emergency (provide ready access to appropriate fire-response equipment, e.g. foam extinguishing capability), carry out routine checks of the proper functioning of firefighting equipment, and undertake regular drills with all affected personnel.

Table 14 Recommended Operating Practices for Chemical Handling and Storage

Operation	Recommendations
Unloading chemicals	**Objective:** To assure that unloading of treatment chemicals occurs in a safe manner (as per section 4 of the NFCC).
• Creosote • Petroleum oil	• Assure that the delivery of preservative chemicals is undertaken by personnel who are trained in emergency response procedures (as required by federal TDGR). • Assure that personnel engaged in transfer of petroleum oil and creosote are trained as per the NFCC, i.e. emergency procedures, constant attendance during unloading, operation of fire protection equipment and emergency shutoff valves. • Consult with section 4 of the NFCC regarding transfer operations of combustible materials via different modes of transport, e.g. rail, truck, ship unloading procedures, grounding, etc. • Assure that ready access to emergency advice and aid is available during all chemical unloading periods, i.e. train employees in standard procedures for normal operations, as well as for emergencies, and post procedures in printed form for reference (NFCC and TDGR). • Restrict access to the unloading area during chemical transfer operations.
Storage of wood preservation chemicals	**Objective:** To assure that all creosote solutions are safely stored.
• Creosote • Petroleum oil	• Assign responsibility for storage areas to trained personnel. • Label storage areas and tanks with the identity of contents by chemical name, type of solution and concentration (e.g. creosote, creosote/oil work solutions). • Place chemical identity placards, fire or spill emergency response procedures, personnel safety precautions and first aid procedures at storage room entrances and/or at storage areas. • Implement visual inspection routine at least once each shift for prompt detection of abnormal conditions (as per the NFCC). • Frequently inspect and test all safety shutoff valves and other fire safety devices (as per the NFCC).

NFCC = National Fire Code of Canada.
TDGR = Transportation of Dangerous Goods Regulations.

Table 15 Recommended Operating Practices for Treatment and Post-Treatment Procedures

Operation	Recommendations
Treatment	• Follow good housekeeping practice to minimize preservative contamination from wood debris, soil and water. • Condition wood adequately to minimize after-bleeding. • Keep net retention as close as possible to specified levels. • Apply as a minimum after the impregnation cycle an effective final vacuum to equilibrate internal wood pressure and to cool the wood. • To minimize bleeding, apply an effective expansion bath or final steam/vacuum cycle.

Table 16 Recommended Operating Practices for Process Systems

Operation	Recommendation
Post-treating checks Charge removal	• Avoid exposure to vapours by working upwind of charge and/or by wearing an approved respirator.

Table 17 Recommended Operating Practices for Maintenance, Cleanout and Shutdown of Treatment Systems

Operation	Recommendation
Equipment maintenance	• Carry out welding and cutting operations in accordance with the National Fire Code of Canada. – Thoroughly clean surfaces to be welded (residues and components of creosote are flammable.) – Provide good ventilation in the work area. – Contain all sparks and remove flammable materials from the vicinity of the repair area.

9 Process Emissions and Disposal

9.1 Control, Treatment and Disposal

The creosote pressure treatment process generates liquid and solid wastes and emissions to air. Numerous approaches are used or can be used by the industry to control, treat and/or dispose of the process wastes and emissions. Potential sources of chemical releases from creosote pressure treatment facilities were described in section 5.2 and Figure 2. Table 18 identifies the main categories of process wastes or emissions that can be generated at creosote facilities, and summarizes recommended control, treatment and/or disposal methods.

Table 18 Recommended Disposal Practices for Creosote-Contaminated Wastes

Waste category	Examples	Recommendations
Liquid creosote or creosote/oil solutions	• Preservative work solutions • Material skimmed from oil separators • Drips from freshly treated lumber	• Collect and reuse (standard practice at creosote/oil plants). • Recover and reuse (successfully demonstrated at some oil-borne plants).
Liquid creosote/water solutions	• Condensates • Washwaters • Infiltrating waters	• Treat to remove oil and creosote to within regulatory limits. • Reuse retrieved oil and creosote, e.g. from gravity separation. • Dispose of treated waters as per regulatory requirements.
Contaminated solid wastes	• Debris and bottom sludge from storage tanks, sumps and pressure cylinders • Soils contaminated by spills • Cleanup absorbents	• Drain and/or drum, store and dispose of in accordance with provincial regulatory requirements (high-temperature thermal destruction is considered a feasible disposal option).
Miscellaneous solid wastes	• Scraps, cuttings and shavings from creosote-treated lumber	• Dispose of in sanitary landfills (subject to approval by the municipal and/or provincial regulatory agency).
Contaminated storm runoff	• Any storm runoff or contaminated liquid discharge that is determined to be toxic to fish at the point of discharge (toxicity is determined by bioassay tests of specific discharges)	• Prevent or minimize contamination of storm runoff to the greatest possible extent. • Monitor surface water discharges (in consultation with the provincial regulatory agency) to assess contaminant concentrations and to determine the need for control.
Firefighting water runoff	• As above (contaminated storm runoff)	• Consider containment provisions in areas where creosote and creosote/oil solutions are present. • Consult with the provincial regulatory agency to determine acceptable disposal practices.

9.2 Waste Liquids Containing Creosote

Liquid Process Wastes

Leaks and drips of oil solutions are contained and reused in the treatment process. Liquids such as condensates, washwaters and infiltrating waters, which cannot be reused, must be treated to remove creosote and petroleum oil prior to discharge (31, 32, 33). The treatment techniques may include one or a combination of:

- oil/water API separation, or plate separation;
- gravity separation in settling tanks;
- activated sludge treatment;
- activated carbon treatment;
- physical-chemical treatment (e.g. flocculation);
- evaporation/condensation.

A regulatory discharge permit must be obtained for disposal of the treated wastewaters.

Contaminated Storm Runoff

Because creosote wood preservation facility sites are generally large, considerable volumes of storm runoff occur from these sites. Precautions should be taken to avoid contamination of storm runoff water, particularly in the vicinity of creosote treatment areas, treated wood discharging areas and storage sites. It is good practice to roof the process areas, including the pressure cylinder and associated equipment, since this practice reduces contaminated storm runoff. Discharging areas should be paved and bermed, with provisions for collection of surface runoff. The likelihood of creosote-contaminated runoff from treated wood storage areas must be acknowledged, and surface runoff from the storage areas should be monitored for creosote and oil. If contamination is evident, and if the runoff is directed to a waterbody or a storm sewer, the need for control of the discharge will have to be determined in consultation with the appropriate regulatory agency.

Control Requirements

Control specifications will depend upon factors such as the volume and frequency of the discharge and the sensitivity of the receiving environment. The discharge of creosote-contaminated emissions into waters inhabited by fish is subject to the federal *Fisheries Act*.

9.3 Solids with Potentially High Creosote Concentrations

For the purpose of this document, solids with potentially high levels of creosote are defined as:

- sludges from sumps, work solution tanks and pressure cylinders;
- sludges from wastewater treatment processes (e.g. flocculated material);
- "spent" activated carbon.

Activated carbon contaminated with creosote can be regenerated, in which case it should not be considered a waste.

While awaiting disposal, the contaminated solids should be stored in leakproof containers in a specially designed area that is curbed and lined with impermeable material. The area should be roofed to protect the wastes from precipitation. Any seepage or leachate generated at the site should be contained. It should be noted that several provinces limit the volumes of creosote wastes that can be stored.

The wood preservation industry in Canada has the following options for handling and disposal of creosote-contaminated solids:

- on-site storage until hazardous waste disposal facilities have been constructed and are operating in Canada;
- shipment to the United States for high-temperature incineration;
- incineration of the wastes following approval by the appropriate provincial regulatory agency;
- disposal at hazardous waste landfill sites.

At the moment, incineration of creosote-contaminated wastes has not been reviewed by Environment Canada to determine whether guidelines are needed.

9.4 Miscellaneous Solid Wastes

Miscellaneous solid wastes (creosote-treated wood and containers used to store creosote) from creosote wood preservation plants may be disposed of at sanitary landfills designated by the provincial regulatory agency. Containers must be steam-cleaned prior to disposal.

9.5 Air Emissions

Air emissions at creosote pressure treatment facilities are generally localized; effects, if any, would be restricted to workers at the facilities. Such emissions may include:

- vapours from tank vent;
- vapours from opening of retort cylinder doors;
- vapours from freshly treated charges;
- vapours from vacuum system outlets.

Analyses of air emissions from creosote facilities indicate that the components are mostly low molecular weight organic compounds (20).

Design and procedural recommendations for control of localized emissions are suggested in sections 7 and 8.

10 Emission and Site Monitoring

Site monitoring and assessment are recommended at creosote facilities, in accordance with the design and operating objectives described in this document, to verify that wood preservative chemicals are properly managed at the site and to ensure environmental and worker health protection.

Environmental monitoring programs may normally be developed in consultation with provincial regulatory agencies and, where applicable, Environment Canada, whereas worker health monitoring programs may be developed in consultation with a provincial workers' compensation board and/or department of labour.

A program needs to ensure that adequate monitoring sites and frequencies are selected and that the preservative constituents, detection levels and quality control are defined. The appropriate components of a site and worker exposure monitoring program are contained in Part I, Chapter A - General Background Information and Recommendations, Tables 14 and 15.

Analytical methodologies proposed for use must be approved by the regulatory agencies. Constituents (analytes) to be identified and quantified should include some indicators of petroleum oil contamination, for example, oil and grease analyses using methods 503 B or 503 E in Standard Methods (34) and selected components of creosote. Components of creosote selected by other investigators for monitoring have included naphthalene and 1-methyl and 2-methyl naphthalene (39); 2,4-dimethyl phenol and 3,5-dimethyl phenol (38); and phenol. Fluorescence spectroscopy (35) has been successfully used for field assessment of creosote in soils and waters (36).

All analytical data need to contain documentation that will 1) trace the sample from the field to the final results, 2) describe the methodology used, 3) describe the confirmatory evidence, 4) support statements about detectability, 5) describe the quality assurance program and demonstrate adherence to it, and 6) support confidence statements for the data (37). It should be noted that field kits for the colorimetric analysis of PAHs in soils and water are available.

11 Transportation of Creosote Solutions and Wastes

The transportation of creosote, oils for blending and creosote wastes are regulated under the federal *Transportation of Dangerous Goods* (TDG) *Act*. The act does not apply to the transportation of creosote treated wood or treated wood wastes. The regulation of intraprovincial movement of dangerous goods is a provincial responsibility.

The stipulated transportation procedures are abstracted in Part I, Chapter A - General Background Information and Recommendations, section 11. It should be noted that creosote (coal tar distillates) is listed in the TDG regulations and is cross-referenced to wood preservatives, which are classified as flammable liquids.

12 Spill and Fire Contingency Planning

Preparedness for emergencies is essential in any wood preservation plant. Hence, facilities using creosote or creosote/oil solutions should prepare and have readily available detailed contingency plans to ensure that response to spills and fires is quick, safe and effective.

12.1 Spill Contingency Planning

Use the recommendations made in the corresponding section 12.1 of Part I, Chapter A - General Background Information and Recommendations.

12.2 Fire Contingency Planning

Creosote is a combustible liquid. An irritating heavy, black smoke forms with a creosote fire. Although water is ineffective as an extinguishing medium and should not be used directly on the fire, it should be used to cool fire-exposed containers. Proper fire extinguishing agents are dry chemical, foam or carbon dioxide, and a water fog.

Other recommendations, as outlined in section 12.2 of Part I, Chapter A - General Background Information and Recommendations, apply.

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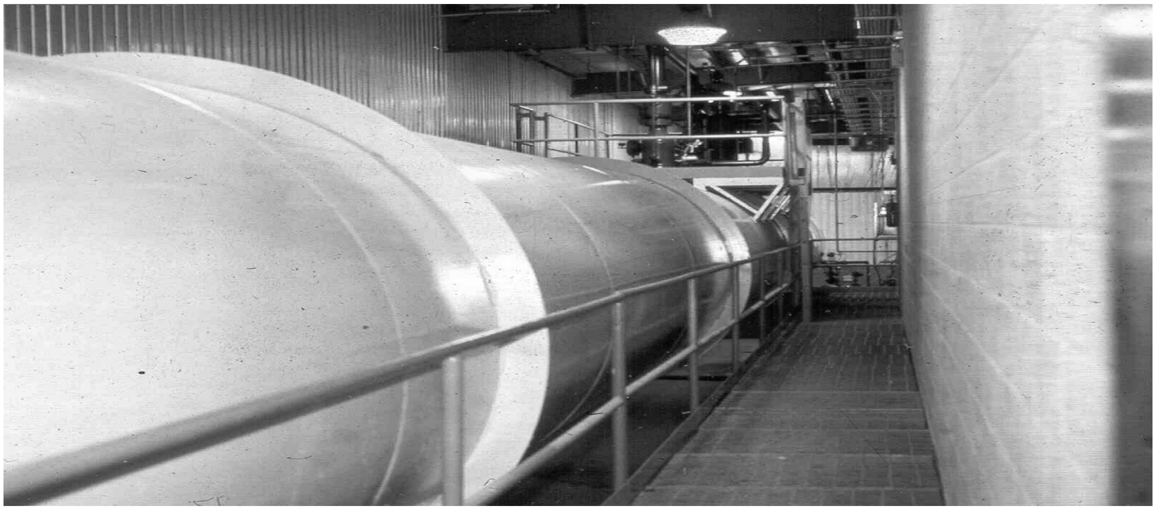

CHAPTER E

Pentachlorophenol Pressure (PCPP) Wood Preservation Facilities

Preservative-specific Information and Recommendations

This chapter must be used in conjunction with Part I, Chapter A - General Background Information and Recommendations for Wood Preservation Facilities.

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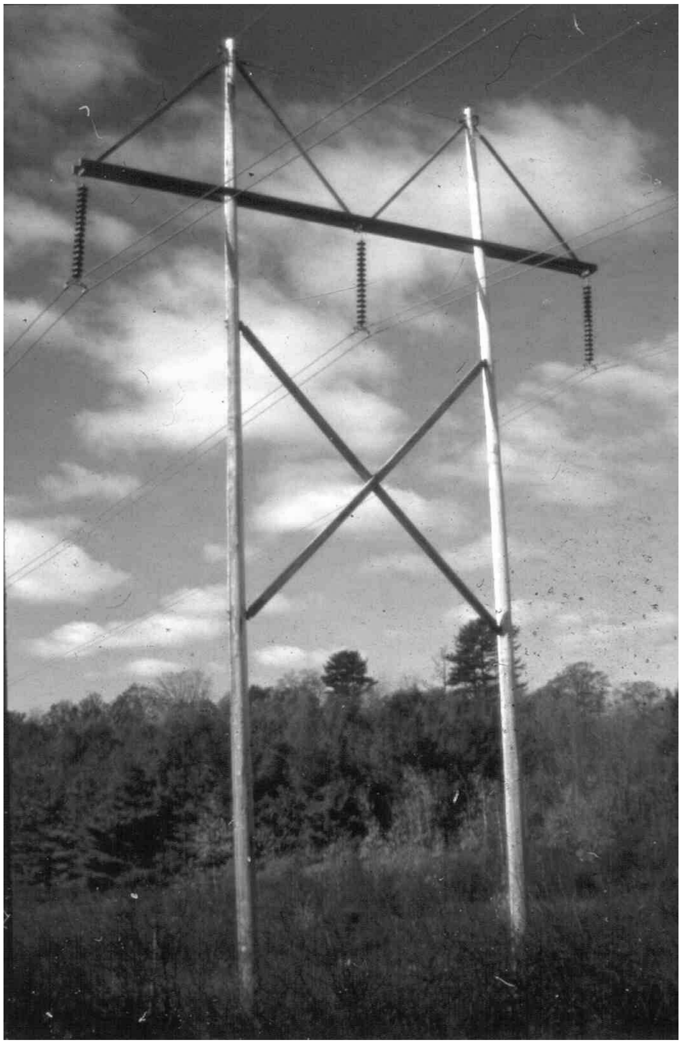

Pentachlorophenol[*] (PCP) was first used as a wood preservative in 1936 (1). The biological properties of PCP have resulted in its use as an antimicrobial agent in industrial cooling systems and papermaking, and as a fungicide in protein-based latex paints (2). Agriculture Canada restrictions in 1981 limited the use of PCP for preservation of outdoor wood products. The use quantities in 1992 were 1442 tons (3). PCP use by the wood preservation industry depends primarily on the size of the pole and cross-arm markets: CCA has partially replaced PCP in the utility pole market, and the PCP tie market has recently been converted to creosote/oil treatments, leading to a use decline since 1981, when its consumption was about 1600 tons (4). Table 1 provides an overview of PCP usage at Canadian pressure and thermal treatment facilities.

PCP is prepared by reacting chlorine with phenol in the presence of a catalyst at high temperatures. PCP was last manufactured in Canada in 1983. It is now obtained from one of two U.S. manufacturers, who supply it in the form of solid blocks (900 kg or 2000 lbs.) and bags of flakes. The petroleum oils used as carriers for PCP are purchased from Canadian sources. The oils must conform to standard CAN/CSA 080.201.

PCP/oil mixtures are used for pressure treatment of wood products such as telephone and electrical utility poles, cross-arms, posts and construction timbers. Over 90% of all PCP is used for utility pole preservation. The pressure-impregnated PCP is retained by the wood, and its bio-effectiveness protects the wood against fungi and insects. In addition to functioning as a carrier of PCP, the oil also provides extra protection against moisture content changes, leading to greater wood stability and resistance to splitting. For utility pole use it has the additional advantage of providing resistance to electrical currents and facilitating the climbing of poles by line personnel.

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[*] The technical product referred to as "PCP" in this document is not pure PCP. It contains 86% PCP and 10% "other chlorophenols and related products." Related products include trace amounts of some polychlorinated dibenzo-p-dioxins, polychlorinated di-benzo furans and hexachlorobenzene. Use of the term "PCP" in this document is consistent with industry nomenclature and refers to the technical grade product.

Table 1 Overview of PCP Usage in Canada

Feature	Characteristics
Delivery format	900 kg (2000 lbs.) (solid blocks)
Concentration of active ingredients	Described by manufacturers as "86% PCP, 10% other chlorophenols and related compounds and 4% inerts."
Suppliers to Canadian facilities (1995)	• Vulcan Materials Co., Birmingham, AL • KMG-Bernuth Inc., Houston, TX
Estimated use by pressure and thermal treatment facilities (1992)	1 442 000 kg (3)
Concentration of work solutions	5% to 8% in petroleum oil
Typical preservative retention in treated wood	6.4-12 kg PCP/m^3 of treated wood (0.4-0.75 lbs./ft.^{3})
Major products treated in Canada	Utility poles, cross-arms, posts and construction timbers (railroad ties are not treated with PCP at this time)

2 Physical and Chemical Properties

PCP is a solid at room temperature. It can be characterized as a stable organic compound, which is sparingly soluble in water and highly soluble in organic solvents. It adsorbs strongly to organic solids such as cellulose in wood.

PCP is chemically and biologically persistent in high concentrations (e.g. the 5-8% concentrations used for treatment of wood). Its persistence in treated wood and its toxicity to wood decay organisms are two major reasons for the use of PCP as a wood preservative. However, it is photodegradable and at low concentrations is also biodegradable.

Table 2 summarizes the physical and chemical properties of PCP (5, 6). The physical and chemical properties cited below must be given special consideration during handling and contingency planning:

- the ability of PCP to dissolve in water, with increasing dissolution occurring with increasing pH and increasing temperature;
- the high solubility of PCP in oils, including skin oils, which enhances its ability to penetrate skin following dermal contact;
- the potential to form toxic fumes upon exposure to fires and high temperatures (i.e. over 350°C);
- a vapour pressure (although low at room temperature) that will result in a small degree of sublimation of PCP.

Table 2 Physical and Chemical Properties of PCP Solids

Identification		
Common synonyms: (past and present) Chlorophen Cryptogyl O1 Dowicide 7 Dowicide G Penchlorol Penta PCP Santobrit Santophen 20 Witophen P	Manufacturers: • Vulcan Materials Co., Birmingham , AL • KMG-Bernuth Inc., Houston, TX	
Transportation and storage information		
Shipping state: Solid (blocks, flakes) Concentration: 96% by weight total (technical grade) chlorophenols (86% PCP) Classification: Poisonous	Storage temperature: Ambient Inert atmosphere: No requirement Venting: Open Containers/materials: Solid blocks with polyethylene wrap	Labels and classification: Check with the Department of Transport
Physical and chemical properties		
Physical state: Solid Solubility: Freely soluble (oil) Slightly soluble (water) 5 ppm by weight (0°C) 14 ppm (20°C) 35 ppm (50°C)	Floatability: Sinks in water Specific gravity: 1.98 (22°C) Vapour pressure: 0.00011 mm Hg (20°C) 40 mm Hg (211°C) Boiling point: Decomposes at 310°C Odour: Strong pungent odour when heated Vapour density: 9.2	Appearance: White to light brown solid Melting point: 188 to 191°C Flash point: Not flammable Explosive limits: Not flammable
Hazard data		
Fire: *Extinguishing data*: Use water spray, dry chemical, foam or carbon dioxide. (Note: fire residues may contain chlorinated furans or dioxins and must be treated as contaminated.) Use water to cool fire-exposed containers. *Fire behaviour*: When heated to decomposition, toxic fumes of hydrogen chloride are formed. Chlorinated dioxins may be generated. *Ignition temperature*: Not combustible *Burning rate*: Not combustible	**Reactivity:** *With water* : No reaction **With common materials:** Can cause deterioration of rubber when dissolved in oil. **Stability :** Stable	

3 Environmental Effects

The exposure of aquatic organisms to PCP could result in both short-term (acute) and long-term (chronic) toxic effects. At low concentrations, PCP is not considered a persistent contaminant in the environment, because of documented photochemical degradation and microbial breakdown in surface waters, soil media and sewage effluents (7). However, as noted in section 3.1, PCP is widespread at low concentrations in the environment (7). The environmental effects are dependent upon a complex array of parameters including concentration, pH, adsorption to suspended solids, temperature, biodegradation rate and photodecomposition rate.

3.1 Distribution in the Natural Environment

PCP has been detected in snowpacks, water, landfill leachates, sewage effluents, sediments, and aquatic and terrestrial organisms (2, 7, 8, 9). Many sources of PCP releases are suspected. These include disposal areas used for various commercial formulations used historically as slimicides and fungicides, storage areas for PCP-treated products (including the former process of lumber dipping or spraying with aqueous solutions of chlorophenates for sapstain control), accidental or uncontrolled process releases from wood preservation facilities, and chlorinated wastewaters, especially those from pulp and paper mills and municipal sewage treatment plants (9).

PCP is not a natural compound and its environmental background level should be "zero." However, anthropogenic sources have resulted in trace concentrations even in remote areas. For example, levels of 0.003 mg/L to 23 mg/L have been detected in many tributaries and bays of each of the Great Lakes. Supposedly remote areas have frequently shown levels of 0.01 mg/L. A survey of the Fraser River showed PCP concentrations ranging from 0.002 to 0.0037 mg/L in waters sampled upstream of industrial areas (8). The reported trace concentrations illustrate the high degree of detection capability, i.e. to a fraction of one-billionth of a gram of PCP in a litre of water. These concentrations are much lower than concentrations that have been found to affect aquatic biota or human health (9). The restricted uses of PCP implemented during the early 1980s, as well as the cessation of chlorophenate uses for antisapstain treatments, may since have had a positive impact on the current levels of PCP in the Canadian environment.

3.2 Environmental Criteria

Based on extensive reviews of the literature and unpublished information, regulatory agencies have derived upper limits for PCP in the environment. As of July 1987, upper limits for Canadian waters have been defined under the auspices of the following regulatory agencies or commissions: the International Joint Commission (IJC) for Great Lakes waters (9); Health and Welfare Canada for maximum acceptable concentrations in drinking water (15, 46); the Ontario Ministry of Environment for protection of aquatic life; the B.C. Ministry of Environment and Parks for waters of the Fraser River (12); and the Canadian Council of Resource and Environment Ministers (13). The upper limits are summarized in Table 3.

Table 3 Regulatory Limitations for PCP in Natural Waterbodies

Limit type	Limit value	Basis	Agency
Maximum acceptable(a) concentration	3 µg/L	To protect drinking water (based on the odour threshold, which is more sensitive than the toxic threshold for humans)	Health and Welfare Canada, 1989 (15)
Recommended maximum concentration	20 µg/L	To protect human health (ingested with water)	U.S. Environmental Protection Agency, 1986 (10, 11)
Objective	0.4 µg/L	To protect Great Lakes aquatic life	International Joint Commission, 1980 (9)
Criteria	Examples(b) 5.5 µg/L at pH = 6.5 20 µg/L at pH = 7.8 68 µg/L at pH = 9.0	To protect freshwater biota • 1-hour average concentration not to exceed the calculated numerical value more than once every 3 years on the average	U.S. Environmental Protection Agency, 1986 (10)
	Examples(c) 3.5 µg/l at pH = 6.5 13 µg/L at pH = 7.8 43 µg/L at pH = 9.0	• 4-day average concentration not more than once every 3 years on the average.	
	7.9 g/L	To protect saltwater biota • 4-day average concentration not to exceed the criterion more than once every 3 years on the average.	
	13 µg/L	• 1-hour average concentration not to exceed the criterion more than once every 3 years on the average.	
Objectives(d) (Fraser River)	0.2 µg/L 100 µg/kg (wet weight) 10 µg/kg (dry weight)	Maximum in water Maximum in fish Maximum in bottom surface sediments	B.C. Ministry of the Environment (12)
Objective	0.5 µg/L	To protect all forms of life in receiving waters	Ontario Ministry of the Environment
Guidelines	0.5 µg/L	To protect aquatic life	Canadian Council of Resource and Environment Ministers (13)

(a) “Maximum acceptable concentration” is defined by Health and Welfare Canada as follows: “Drinking water that contains substances in concentrations greater than these limits is either capable of producing deleterious health effects or is aesthetically objectionable.”

(b) Expressed as an exponential function: PCP limit (mg/L) = exp(1.005(pH)-4.830).

(c) Expressed as an exponential function: PCP limit (mg/L) = exp(1.005(pH)-5.290).

(d) Sum of tri-, tetra- and pentachlorophenol.

4 Human Health Effects

One safety objective of industrial usage of any chemical is to minimize worker exposure. If safeguards are not provided or not implemented, a variety of human health effects can occur depending on the duration and manner of exposure, concentration of the chemical to which exposure has occurred, form of the chemical (e.g. ionic vs. nonionic), and the varying metabolic sensitivities of individual workers.

4.1 Known Effects

On the basis of information from existing literature, Table 4 outlines the spectrum of human health effects that could result from various degrees of exposure to PCP (16). Overlaps of different exposure categories are noted in the table and reflect real situations, which may be due in part to the variable individual sensitivities.

Table 4 Range of Possible Human Health Effects from Exposure to PCP

Exposure category		**Possible health effects**	
	Relative level of chlorophenol in the body*	Short-term exposure	Long-term exposure
General population, e.g. chlorophenol intake from environmental sources	1	None	None
Properly protected worker — minimal exposure	1 to 100	None	None
Exposed worker with moderate skin contact and/or moderate exposure to vapours or dusts	17 to 200	Irritation of skin, eyes, upper respiratory system; possible increased metabolism	
Worker with significant overexposure, e.g. frequent skin contact, exposure to high dust levels	33 to 1 000	Profuse sweating, headaches, nausea, weakness, fever, intense thirst	Dermatitis; chloracne; suspected damage to kidney, liver, nervous system; weight loss
Major accidental overexposure, e.g. ingestion	833 to 30 000	Death from heart failure	

* The “relative level” values are based on urine monitoring data presented in reference 16. The numbers are illustrative only and indicate the order of magnitude of chlorophenol exposure that might be experienced under varying conditions of exposure. Background levels of chlorophenol in urine for the general population vary from 5 to 40 parts per billion.

Many reviews have been published on the potential and known health effects of overexposure to PCP, including those of Williams (17), Wood et al. (18), Jones (2), the American Conference of Governmental Industrial Hygienists (19), the International Labor Organization (20), the United Nations Environment Programme (21), the U.S. National Institute for Occupational Safety and Health (22, 23), the U.S. Environmental Protection Agency (11, 14) and the U.K. Advisory

Committee on Pesticides (47). A 1987 review of health effects is provided by Health and Welfare Canada in an Agriculture Canada discussion document on PCP (24).

4.2 Special Sensitivity

Natural sensitivity to the toxic effects of PCP exposure varies. Some workers may be especially sensitive, including individuals with pre-existing skin problems, a history of liver or kidney disease, or a history of metabolic disorders caused by conditions such as diabetes or thyroid disease (23, 31). Prior to employment, workers should be informed of such sensitivities. The information should not be used to bar workers from employment but to assure that proper precautions are applied. For reasons of prudence it is suggested that pregnant women not be exposed to excessive levels of PCP.

4.3 Conclusions

There is a large database on the potential effects of PCP on the environment and on human health. The database has been intensively reviewed by regulatory bodies and organizations such as the International Labor Organization, the American Conference of Governmental Industrial Hygienists, the United Nations Environmental Programme, Environment Canada, the International Joint Commission, the U.S. Environmental Protection Agency and the U.K. Advisory Committee on Pesticides. An Agriculture Canada discussion document on PCP also provided a review of the database (24). These reviews have promoted an awareness of the precautions necessary in handling and using PCP.

This document is in agreement with the conclusions of agencies such as the International Labor Organization (20) and reviewers such as Williams (17) that PCP can be used in industry without undue health risks to occupationally exposed workers, provided that certain precautions are taken to assure that workers are adequately trained in the proper use of protective equipment and in hygiene practices, and that facilities are designed to minimize air concentrations and skin exposure. Similarly, as has been demonstrated at many existing facilities, protective measures can be installed to adequately protect the environment from PCP releases.

5 Description of Preservative Application and Potential Chemical Discharges

In 1993, there were 14 pressure impregnation facilities applying PCP/oil in Canada (3). At these plants, design and operating practices are highly individualized. The plants mostly depend on internal resources to deal with environmental issues (32).

5.1 Description of Process

PCP is generally purchased as solid blocks, usually of 907 kg (2000 lbs.). Two U.S. suppliers are involved. Petroleum oils used as carriers for PCP are purchased locally and delivered by bulk truck or rail tanker and are stored in exterior tanks.

After delivery of PCP and the carrier oils, the following process steps occur:

Chemical Mixing

The PCP blocks are dissolved by placing them in the treatment cylinder (or into a mix tank) and recirculating heated oil between the cylinder (or mix tank) and the bulk storage tanks. A concentrated solution may first be prepared. The concentrate is then diluted to working concentration (5-8% PCP) by recirculation between the cylinder (or mix tank) and the bulk storage tank.

Wood Conditioning

Prior to application of the PCP/carrier oil mixture, the moisture content of the wood is reduced by one of several conditioning processes. Conditioning of the wood may be achieved by air seasoning, kiln drying, or by processes carried out in the treatment cylinder, for example, application of steam and subsequent vacuum, or boiling under a vacuum in the presence of the treating solution (Boultonizing). In Canada, steaming is the most common means of conditioning poles, which make up 90% of the total PCP-treated material (3).

Preservative Application

The preservative is applied in a pressure cylinder, which may be up to 45 m long and 2 m in diameter. Specific treatment parameters (e.g. temperature, pressure and duration) are dictated by the species of wood, the wood product and initial moisture content of the wood. Many of the operating parameters, preservative standards and product quality characteristics (e.g. penetration and preservative retention) are defined by the Canadian Standards Association (33).

After conditioning, an empty-cell treatment process is generally used to apply the oil-borne PCP preservative. Following the drain cycle at the end of the impregnation process, a vacuum is applied to encourage the removal of excess preservative and pressurized air from the wood cells. This process minimizes preservative “bleeding” from the treated product. Alternatively, an expansion bath or final steam cycle, followed by a vacuum, may be used to minimize surface exudations and long-term bleeding.

Storage of Treated Product

The treated wood is withdrawn from the treating cylinder and put on a drip pad. The time on the drip pad depends on the facility schedule and design. For example, at a facility with a double tracking system, the drippage time may be equivalent to the duration of a treatment cycle for another charge. The treated wood is removed from the drip pad by forklift and stored in a designated area until transport to the customer.

5.2 Potential Chemical Discharges

PCP wood preservation facility design and operational practices vary (34, 35), and each facility has potential sources of emissions that could affect worker health and/or the environment. The potential sources and releases are illustrated in Figure 1.

Liquid Discharges

Leaks and drips of oil solutions can be contained and reused in the oil-borne treatment process. Liquids that cannot be recycled and reused include the following:

- condensates removed from the wood during conditioning and during the initial application of vacuum;
- water released by the wood during the treating cycle and subsequently separated from the unabsorbed treatment oil prior to recycling of the oil;
- washwaters.

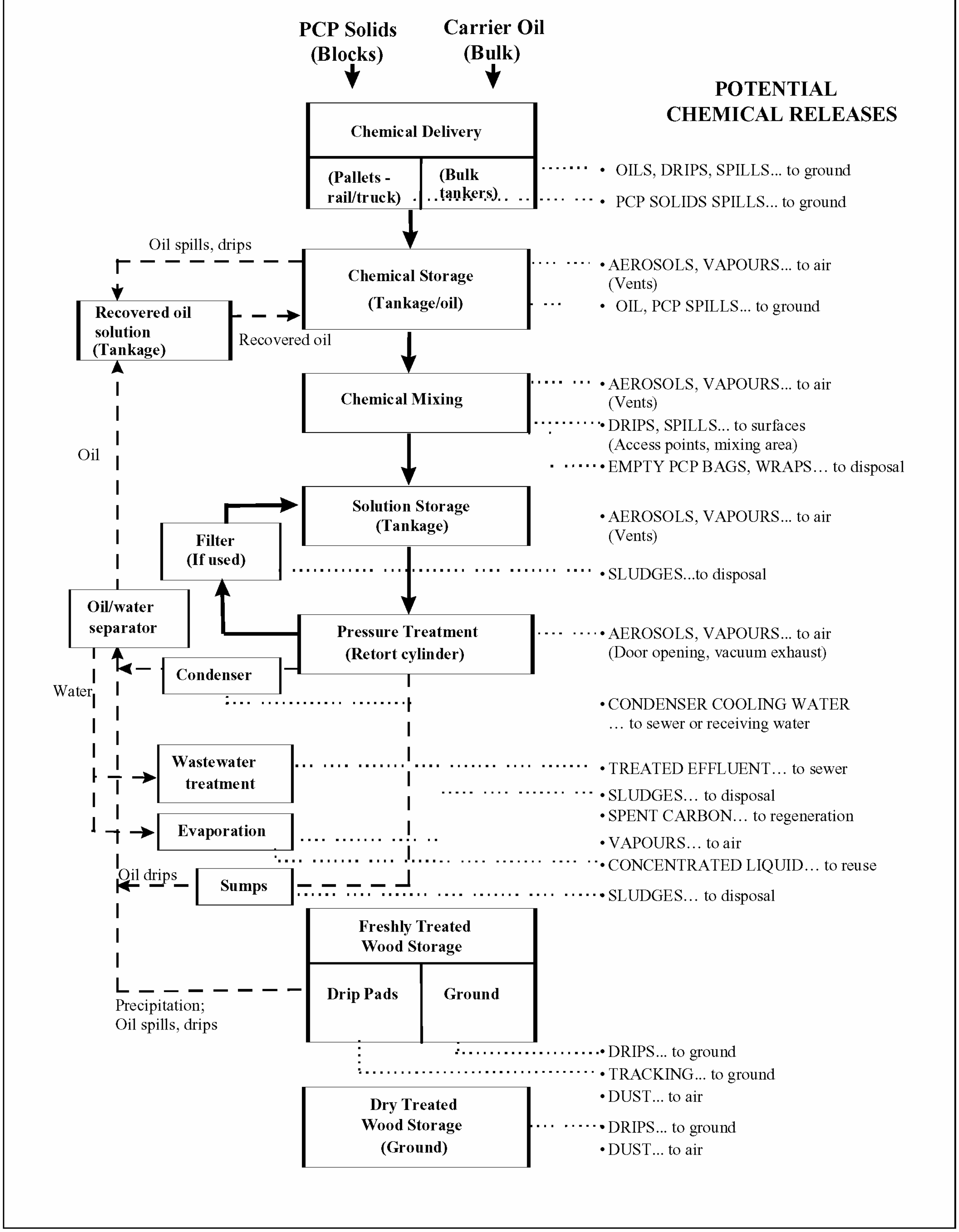
These liquids can contain PCP and must be treated before discharge as a waste stream.

Other liquids that may be released from oil-borne PCP facilities may include the following:

- steam condensates from indirect heat transfer in cooling and heating coils, which are generally checked for contamination prior to discharge;
- condenser cooling waters, which are not normally contaminated and are discharged without treatment;
- surface runoff from treated wood storage areas, which can contain preservative.

The PCP content in runoff waters depends on many factors, including drip and vacuum time in the last step of the pressure process; viscosity of the wood preservative; wood species; moisture content of the wood prior to application of preservative (i.e. adequacy of conditioning step); specific treatment process (i.e. Rueping or Lowry); effectiveness of the post pressure cycle processes applied (expansion bath, final steaming, final vacuum); and exposure to the weather. The need for control of runoff waters depends on analytical and/or bioassay evaluations and regulatory requirements.

Figure 1 Potential Chemical Releases from PCP Pressure Treatment Plants



Solid Wastes

Solid wastes from PCP oil-borne pressure treatment facilities may include:

- sludges from tanks, sumps and pressure cylinders;
- sludges from wastewater treatment processes (e.g. flocculated material);
- containers or wrappings and pallets from bulk penchlorophenol; and
- contaminated soils.

Air Emissions

Air emissions from PCP oil-borne pressure treatment facilities are generally localized and may include:

- vapours from block storage;
- emissions during wood conditioning and the final vacuum step;
- vapours from tank vents;
- vapours from venting cylinders;
- vapours from opening of cylinder doors;
- vapours from freshly treated charges.

5.3 Potential Effects of Chemical Discharges

The actual impact of any chemical release to the environment depends on many factors, including the location of the wood preservation facility relative to ground or surface waters, the species of aquatic biota in adjacent surface waters, and the amount of preservative released. Variables that can influence effects on worker health include ambient concentrations, frequency of exposure and protective measures during the time(s) of exposure.

All PCP pressure treatment facilities have a potential to affect the environment, as do any other chemical-using industrial facilities, if proper control measures are not in place. Documented PCP releases from wood preservation facilities have been due to either poor design or poor operating practices. The effects of these releases appeared to be either localized within the plant site (i.e. soil and groundwater contamination) or in the environment immediately adjacent to the plant site.

Localized site contamination (soil and groundwater) - that was due to poor design and operating practices and which required extensive control and/or cleanup measures - has been reported from several PCP pressure treatment operations in Canada (2, 36, 37).

Fires at Canadian wood preservation sites have also been documented (38, 39, 40). The incidents illustrate the need for proper contingency planning for fire control and for containment of oil solutions and fire runoff waters.

Human health could be affected if appropriate precautions are not taken during manual preparation of PCP solutions, minor spills in working areas, and handling of treated products.

6 Personnel Protection

With the use of PCP, it is important to provide protection for all potential types of exposure: eye contact, skin contact and inhalation. Many work situations require protection against more than one type of exposure, for example, when chlorophenol dusts, aerosols or vapours are produced. In these situations, the use of nose-mouth respirators that do not cover the eyes and skin around eyes may lead to a false sense of security. Full face shields or full-face cartridge respirators are required.

6.1 First Aid for Accidental Pentachlorophenol Exposure[*]

Table 5 First Aid for Exposure to PCP or PCP Solutions

Exposure	First action	Second action
Eye contact	• Immediately flush eyes with flowing water, occasionally lifting the upper and lower lids. • Flush eyes for at least 15 minutes.	• Use boric acid solution and cortisone ophthalmic drops. • Get medical attention.
Skin contact	• Immediately remove soaked clothing or articles in contact with the skin. • Immediately wash contaminated skin thoroughly with soap or mild detergent and water.	• Get prompt medical attention if the skin becomes inflamed (redness, itchiness or pain).
Inhalation	• Immediately remove the exposed person to fresh air. (Coughing and sneezing occur almost immediately after excessive inhalation of chlorophenols.)	• Apply artificial respiration if breathing has stopped. • Keep the affected person comfortable and quiet. PCP can cause excessive body temperature. • Get medical attention.
Ingestion	• For PCP solids: If the victim is conscious, have that person immediately drink large quantities of water and induce vomiting. • For PCP in oil: Regularly consult with competent medical advisor for updated recommended first and second actions. • Do not induce vomiting.	• Call the poison control centre or an industrial physician for subsequent advice.
Chronic symptoms requiring medical referral	• Dermatitis, headaches, nausea • Hyperthermia, fever, sweating, weight loss • Chloracne	

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[*] Potential exposure to PCP in pressure-treating facilities includes exposure to PCP solids, solutions of PCP in oil (treating solutions), and sludges and contaminated aqueous solutions. Inhalation of vapours, aerosols or dusts can occur.

6.2 Regulatory Controls

Most regulatory criteria established by worker protection agencies are based on threshold limit values (TLVs) and biological exposure indices, as recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). Table 6 reviews the ACGIH-recommended limits for PCP and provides recommendations designed to specifically define acceptable levels of chlorophenol exposure in the wood preservation workplace.

Table 6 Levels of Concern for PCP Exposure in the Workplace

Route of entry	Basis for recommendations	Recommendations/comment
Skin and eye contact	PCP is a skin irritant and can be absorbed through the skin.	• Protective measures should be used by workers in contact with PCP solids or PCP/oil solutions (Table 7). • Avoid direct contact of skin and eyes with PCP solids, PCP/oil solutions or PCP-treated wood. • Sensitive individuals (as defined in section 4.2) should take special care to avoid exposure. *Comment*: Current material safety data sheets should always be readily available to workers.
Inhalation	ACGIH threshold limit value 8-hour time weighted averages (TLV-TWA): PCP: 0.5 mg/m^3 air (Potential contributions to overall exposure can occur through the cutaneous route including mucous membranes and eye, either by airborne, or more particularly, by direct contact with the substance.)	• Full face protection and good ventilation should be used during chemical unloading, mixing and retort openings. • Provide respiratory protection, eye protection and good ventilation: – during manual handling of PCP blocks, – when welding contaminated equipment, – during any activity that might generate PCP vapours, – when PCP mist or dust is present. *Comment*: The permissible concentration of PCP refers to vapours; PCP could also occur in air as an aerosol or in contaminated dust.
Ingestion	The reported lethal dose of PCP for adults ranges from 1 to 3 g (29, 30).	• Prevent the ingestion of any quantity of PCP.

Skin and Eye Contact

The ACGIH has recommended a threshold limit value-time weighted average (TLV-TWA) for PCP, which represents a time-weighted average concentration "for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect." The recommended TLV-TWA value for PCP is 0.5 mg/m^3, and is followed by the designation “skin,” which refers to “the potential contribution to the overall exposure by the cutaneous route including mucous membranes and eyes, either by airborne, or more particularly, by direct contact with the substance” (26).

The ACGIH TLV-TWAs for chemicals are defined with the following provisos:

- “The limits are intended for use in the practice of industrial hygiene as guidelines for good practices or recommendations in the control of potential health hazards and for no other use” (i.e. proof or disproof of the cause of an existing disease or physical condition).
- “The limits are not fine lines between safe and dangerous concentrations.”
- “In spite of the fact that serious injury is not believed likely as a result of exposure to the Threshold Limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical.”
- “When two or more hazardous substances, which act upon the same organ system, are present, their combined effect, rather than that of either individually, should be given primary consideration.”

Recently, the ACGIH has suggested augmentation of TLV workplace evaluations by use of “biological exposure indices (which) may be useful as a guide to safe exposure” (19).

In practice, a wide range of dermal exposure to PCP can be encountered in the wood treatment workplace (i.e. from pure PCP solids to waters containing a few parts per million PCP). Dermal penetration is a significant route of PCP intake, and penetration is enhanced if exposure to PCP/oil solution occurs (23).

A minimal level of protection and hygiene, for example, impermeable gloves and regular clothing changes, should be required for all facility workers who have any potential for dermal exposure to PCP, oil and aqueous solutions of PCP, or freshly treated wood. The level of protection should increase with increasing potential for exposure to PCP.

Inhalation

The ACGIH TLV-TWA values for PCP discussed previously for skin and eye contact would also be applicable to maximum allowable values for inhalation. The ACGIH in its rationale for TLV-TWAs (19) states that PCP “dusts are particularly irritating to the eyes and nose in concentrations greater than 1 mg/m^3. Some irritation may occur at 0.3 mg/m^3. Seasoned workers can tolerate up to 2.4 mg/m^3.”

A review of the literature indicates that many of the documented industrial health incidents involving PCP have occurred as a result of dumping bagged PCP flakes in poorly ventilated areas (18, 22, 23). Other exposures to dusts may occur during activities such as jackhammering of PCP blocks (18) or during cleanup of spilled PCP solids. Adequate designs and operational procedures must be assured to minimize worker exposure to PCP dusts (i.e. adequate local ventilation, use of respiratory equipment, and use of wet or vacuum methods for cleaning of spilled PCP solids). Other potential sources of inhaled PCP include vapours in the vicinity of charge removal areas and in the vicinity of freshly treated wood; and aerosols at improperly maintained facilities (e.g. from leaking seals) or at inadequately designed facilities (e.g. from vacuum pump discharges to work areas).

Ingestion

Oral intake of PCP must be avoided. Ingestion of PCP or PCP-containing liquids is unlikely, if workers follow elementary rules of good hygiene. Acceptable limits of ingestion are not prescribed by regulation, since there is no valid reason for any such intake to occur. The single dose level of PCP known to result in fatality is in the order of 1 to 3 g (29, 30).

6.3 Safety Precautions During Operation

Table 7 Safety Precautions for Personnel Working with PCP Solutions

Objective: To ensure safe workplace practices for each activity during the treatment process.	
Activity	**Recommendations**
Unloading PCP solids	• Wear protective apparel including chemical goggles or face shields, impermeable gauntlets, coveralls, impermeable aprons and impermeable shoes or boots. (Resistance rating of materials: excellent — viton, neoprene, butyl rubber; good — nitrile, polyvinyl chloride (PVC); fair — polyvinyl alcohol, polyethylene.) • Do not wear contact lenses. • Work in well-ventilated areas. • Approved respirators should be readily available. Wear respirators whenever exposure to dust can occur. • Provide an emergency eyewash and shower in the immediate unloading or handling areas. • Provide adequate equipment for safe, controlled handling of blocks and bags, and as appropriate for the specific facility • Do not drop blocks. • Immediately vacuum PCP chips or spilled solids (vacuums should have effectively filtered exhausts).
Preparing PCP work solutions	• Work in a well-ventilated area. • Wear full face protection, organic solvent impermeable gauntlets, coveralls, aprons and shoes or boots for all operations involving handling of PCP solids. • In addition, wear an approved full facepiece respirator whenever dust conditions occur. Respirator cartridges must be NIOSH-rated for protection from “pesticides and organic vapors and dusts.” • Thoroughly vacuum PCP dust and solids from the work area following solution preparation. • Dispose of empty PCP wraps, bags and PCP-contaminated debris according to Table 16. • Thoroughly clean protective equipment after use.
Sampling procedures	• Wear eye protection and gloves impermeable to organic solvents when sampling PCP solutions. • Wear impermeable gloves when taking borings from freshly treated wood. • Clean the outside of sample containers after sampling solutions. • Wash hands thoroughly after all sampling operations.

Table 7 Safety Precautions for Personnel Working with PCP Solutions (continued)

Operation	Recommendations
Cleaning cylinders or storage tanks	• Follow all standard precautions for vessel entry (as per provincial health and safety regulations). • Flush vessels as required to establish safe entry conditions, or use an approved self-contained breathing apparatus prior to entry. • Wear NIOSH-approved respirators (or breathing apparatus as above), organic solvent impermeable gauntlets, outer clothing and boots during all vessel entries. • Always have a standby attendant present and provision for continuous outside communications. • Collect and store contaminated waste material in sealed and labelled drums. • Wash all protective equipment immediately after use. • Shower after completion of cleanup tasks.
Removing treated charges from tanks	• Wear eye protection and organic solvent impermeable gauntlets and coveralls or apron during door openings and when moving loads of freshly treated wood. • Avoid breathing preservative mists. Wear an approved respirator if airborne concentrations are unknown or at or above TLVs.*
Handling treated lumber	• Wear impermeable** gloves, apron and boots if handling treated wood manually. • Wear a respirator if treated wood is handled in enclosed areas (e.g. boxcars). • Change coveralls daily. Wash separately from other laundry.
Handling and maintaining contaminated equipment	• Thoroughly steam-clean or flush contaminated equipment with solvent (e.g. Varsol or equivalent) prior to handling. (Contain all solvent washings.) • Change coveralls daily. • Wear impermeable apron, gloves and boots.
Welding	Welding can produce toxic fumes. In addition to the precautions for handling and maintaining contaminated equipment: • Obtain the specific approval of the plant supervisor before welding. • Block or disconnect lines from tanks before initiating welding operations. • Completely drain and thoroughly rinse tanks or lines prior to welding operations. • Ensure that equipment is completely dry from cleaning solvent residues. • Wear a respirator or provide effective, local exhaust ventilation during welding to prevent potential exposure to toxic fumes. • Assure good general ventilation of the work area. • Comply with all additional provincial workplace safety rules.

NIOSH = National Institute for Occupational Safety and Health.

* An initial workplace monitoring program will have determined the need for respirator use. The results of the program are assumed to be indicative of conditions in subsequent facility operations, unless procedural or design changes have occurred.

** Heavy-duty, lined neoprene or polyvinyl chloride (PVC).

7 Design Recommendations

Tables 8 to 13 present good design features, specifically applicable to PCP pressure wood preservation facilities. The recommendations made here must be used in conjunction with the basic design criteria listed in Part I, Chapter A - General Background Information and Recommendations, section 7.

Table 8 Recommended Design Features for Chemical Delivery Areas

(See also Part I, Chapter A - General Background Information and Recommendations, Table 3.)

Delivery format	Design feature	Recommendations
Bulk liquid Petroleum oil (CSA 080.201) (delivered by truck or rail tanker)	**Objective:** To provide an off-loading area that enhances spill prevention and containment and complies with section 4 of the NFCC.	
	Off-loading pad	• Provide an impervious unloading pad with curbs or dykes; drain to a containment area in accordance with the NFCC.
	Drip control	• Design, install and maintain system to prevent leakage and spillage as per the NFCC.
	Delivery system piping	• Install piping and piping systems in accordance with specifications outlined in the NFCC, i.e. materials, corrosion protection, identification, joints, location and arrangement of pipes, valves, heating, methods of transfer and operating procedures. • Protect delivery systems if there is potential for vehicular impact or physical damage.
	Static protection	• Install acceptable provisions for electric bonding as per the NFCC.
	Backflow prevention	• Install backflow preventers on delivery lines.
PCP Solid blocks, bags	**Objective:** To provide an off-loading area that promotes spill prevention and provides containment for and facilitates cleanup of spilled material.	
	Off-loading area/shelter	• Provide a dry, paved off-loading area with protection from the weather, preferably near the storage area.
	Containment	• Provide for containment of a worst event spill of PCP solids (e.g. from dropped pallet load).
	Area cleanup	• Provide a vacuum cleaner system (with filtered exhaust) for cleanup of solids spilled during unloading and transfer operations.

NFCC = National Fire Code of Canada.

Table 9 Recommended Design Features for Chemical Storage Areas

(See also Part I, Chapter A - General Background Information and Recommendations, Table 4.)

Storage format	Design feature	Recommendations
Bulk liquids • Petroleum oil (CSA 080.201) • PCP/oil working solutions • Drip return	**Objectives:** ◊ To provide positive spill prevention features. ◊ To conform to the NFCC, where applicable.	
	Tanks	• Engineer materials of construction and dimensions in accordance with ASME, CAN and API standards as defined in the NFCC. • Mount tanks on containment pad surfaces within a dyked area (subsurface storage tanks should not be used). • Mount tanks in stable position and anchor securely. • Locate tanks in accordance with the NFCC (i.e. minimum distances from buildings and other tanks). • Evaluate means of controlling contaminated surface waters (e.g. roofing of tanks, runoff water treatment). • Test for leakage prior to backfilling as per the NFCC. • Provide grounding for tanks as per the NFCC. • Provide vent piping for vapour control as per the NFCC.
	Spill containment	• Provide structurally sound and impermeable dykes as per the NFCC. • Provide a dyked containment volume equivalent to 100% of the largest storage tank or vessel within the dyked area plus 10% of the aggregate volume of the remaining tanks or equivalent to 110% volume for single tanks in isolated containment. • Provide for directing all spills, washes and infiltrating water to tankage as per the NFCC. (Contaminated liquids must be treated to applicable limit before discharge.) • Provide surface drainage to prevent pooling of minor spills and washdowns as per the NFCC.
	Piping and valves	• Design according to applicable codes.
	Spill prevention/detection	• Install devices to prevent overflow from tanks as per the NFCC, preferably reliable, independent high-level alarms on tanks (i.e. audible alarms).
	Location	• The preferred location for oil tankage (all solutions) is in an exterior centralized tank farm area that is arranged in accordance with the NFCC.
	Security	• Provide security precautions to prevent vandalism or access to tanks by unauthorized persons (the NFCC requires a firmly anchored fence surrounding bulk storage tanks if their aggregate capacity exceeds 564 000 L).

Table 9 Recommended Design Features for Chemical Storage Areas (continued)

Storage format	Design feature	Recommendations
PCP Solid blocks, bags	**Objective:** To provide sheltered, secure, fire-protected storage of PCP solids.	
	Location	• Provide safe, easy access to the mixing area (design to contain and facilitate cleanup of PCP dust/chips lost during transit to the mixing area).
	Shelter	• Provide storage in an enclosed, secure area, segregated from other chemicals (design to prevent infiltrating precipitation). • Design to prevent fire in PCP storage areas (use of non-combustible construction materials is preferred).
	Ventilation	• Provide adequate ventilation for both routine operations and emergency situations.
	Containment/ cleanup	• Store PCP in a paved, curbed or dyked area with no floor drains (or with effective, positive blocks for drains). • Design surfaces for effective cleanup of spilled material. • Provide a vacuum cleaner system (with filtered exhaust) for cleanup of solids spilled during unloading and transfer operations.
	Security	• Provide effective security against unauthorized access.
	Emergency response	• Provide appropriate measures for rapid, effective fire control with containment of liquid firefighting residues, and treatment to stipulated limits before discharge.
Bulk sludges	Location/shelter	• Locate storage in an exterior or well-ventilated location.
	Containment	• Provide closed tanks in sound condition. • Install tanks in a containment area with impermeable, cleanable floors. • Provide adequate containment capacity for a worst event spill. • Block any drains in the containment area; design to collect infiltrating precipitation for treatment to applicable limits prior to discharge (if contaminated).
	Handling	• Provide transfer equipment for clean, safe sludge handling with minimum worker exposure.
	Security	• Provide effective security against unauthorized access and/or release of tank contents.

Table 10 Recommended Design Features for Chemical Mixing Systems

(See also Part I, Chapter A - General Background Information and Recommendations, Table 5.)

Chemical form	Design feature	Recommendations
PCP • PCP blocks, bags • Petroleum oil	**Objectives:** ◊ To provide a mixing system with effective spill prevention features. ◊ To provide a mixing system that minimizes worker contact with PCP.	
	Configuration	• Mixing by block placement in a closed tank is the preferred method. • Use permanent, closed mixing systems (rigidly piped, tank to tank).
	Location/shelter (mixing tanks)	• Locate in a contained, dry sheltered area (giving attention to worker comfort). • Provide protection against freezing (as applicable).
	Solids handling	• Provide appropriate equipment for safe, controlled lifting and handling of PCP blocks. • Provide a dry, paved area for plastic wrap removal from blocks. • Ventilate to control air levels of PCP during routine operation and during worst event spills. • Provide a vacuum cleaner system (filtered exhaust) for effective cleanup of PCP dust and chips from handling/transfer operations. • Provide local exhaust system and closed solids handling systems (e.g. flexible covers on hoppers) to eliminate direct worker exposure to PCP flakes/granules during unwrapping (e.g. as per NIOSH [41]).
	Emergency response	• Provide features described in “Emergency response” (Table 9).
	Spill prevention	• Install high-level alarms and controls to prevent mixing tank overflow.
	Spill containment	• Provide all applicable features for “Spill containment of bulk liquids” (Table 9).
	Drip containment	• Provide local drip collection at all potential drip points.
	Splash protection	• Discourage open transfer operations. If unavoidable, provide reliable splash protection.

Table 11 Recommended Design Features for Treatment Process Systems: General Recommendations

The recommendations in Part I, Chapter A - General Background Information and Recommendations, Tables 6 and 7 apply to PCP/oil pressure treatment systems.

Table 12 Recommended Design Features for Drip Areas for Freshly Treated Wood

(See also Part I, Chapter A - General Background Information and Recommendations, Table 8.)

Design feature	**Recommendations**
Objective*: To minimize losses of preservative chemicals from treated wood.	
Drip time**	• Provide for sufficient storage area to hold all freshly treated wood until dripping is complete.
Containment	• Immediate drip areas should: – be impermeable (i.e. concrete or other surfaces resistant to attack by oils), – be curbed, – provide for collecting and storing all runoff and infiltrating precipitation (for treatment and controlled discharge under terms of regulatory standards). Where storage of runoff waters would be difficult, roofing should be considered.

* A facility should operate so that after-bleeding is minimal (e.g. good conditioning, final steaming, final vacuum).

** The nature and magnitude of drippage losses depend strongly on oil and wood types, and on process-specific factors.

Table 13 Recommended Design Features for Treated Wood Storage Areas

(See also Part I, Chapter A - General Background Information and Recommendations, Table 9.)

Design feature	**Recommendations**
Objective: To minimize and control releases of contaminated surface waters from treated wood storage areas.	
Storage areas	• Evaluate options for storage area surfaces on the basis of factors such as groundwater usage, extent of bleeding and expected levels of precipitation and leaching. Store drip-free wood under roof, or wrap and provide impermeable flooring when continuing drippage or leaching may cause undue runoff or ground contamination. • Segregate treated wood storage areas from other areas and segregate contaminated from uncontaminated runoff water to minimize the need for water treatment. • Locate storage areas away from surface waterbodies. • Routinely monitor contaminant levels in storage area runoff. Contaminant levels of concern to regulatory agencies may require collection and treatment of storm runoff waters.

8 Operational Recommendations

The recommendations for good operating practices listed in Tables 14 and 15 must be used in conjunction with those in Part I, Chapter A - General Background Information and Recommendations, section 8. They are meant to protect both workers and the environment from harmful exposure to PCP and its solutions.

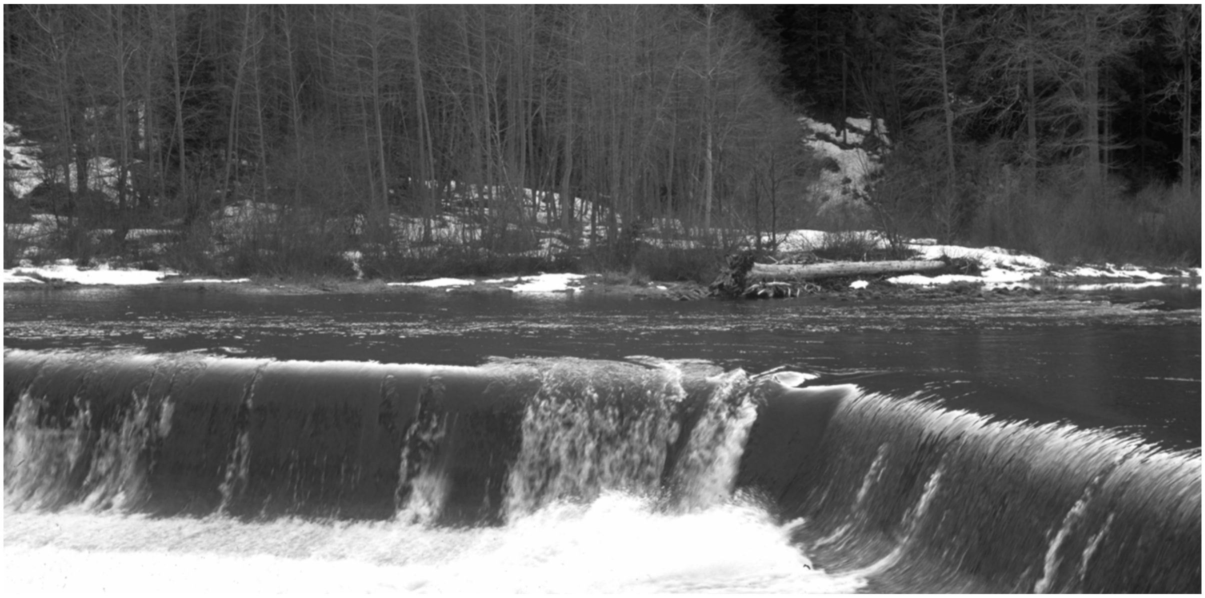
Table 14 Recommended Operating Practices for Chemical Handling and Storage

Operation	Recommendations
Unloading chemicals • PCP solids • Petroleum oil	**Objective:** To assure that unloading of treatment chemicals occurs in a safe manner. • Assure that personnel engaged in transfer of petroleum oil and PCP are trained as per the NFCC, i.e. emergency procedures, constant attendance during unloading, operation of fire-protection equipment and emergency shutoff valves. • Consult with Section 4 of the NFCC regarding the transfer of combustible materials via different modes of transport, e.g. rail, truck, ship unloading procedures, grounding, etc.
Handling of wood preservation solutions • PCP blocks, bags	• Store empty PCP wrappings and dispose of as contaminated wastes in accordance with Section 9. • Contain all spilled PCP solids (dust, chips) and reuse or dispose of as contaminated solid waste.
Storage of wood preservation chemicals • PCP solids • Petroleum oil	• Implement visual inspection routine at least one each shift for prompt detection of abnormal conditions. • Frequently inspect and test all safety shutoff valves and other fire safety devices (as per the NFCC).

NFCC = National Fire Code of Canada.

Table 15 Recommended Operating Practices for Process Systems

Operation	Recommendations
Routine checks	**Objectives:** ◊ To define procedural practices, which will enhance environmental protection and worker safety. ◊ To operate the facility in compliance with the National Fire Code of Canada.
Treatment checks	• Follow good housekeeping practice to minimize preservative contamination from wood debris, soil and water. • Condition wood adequately to minimize after-bleeding. • Keep net retentions as close as possible to specified levels. • Apply as a minimum after the impregnation cycle an adequate final vacuum to equilibrate internal wood pressure and to cool the wood. • To minimize bleeding, apply an effective final steaming/vacuum process.
Post-treating checks Charge removal	• Avoid exposure to vapours by working upwind of charge and/or by wearing an approved respirator. • Wear impervious gauntlets during handling of freshly treated charges. • Maximize use of mechanical equipment for charge removal to minimize need for worker handling of freshly treated wood. • Remove charges only when the superficial excess preservative has drained.



9 Process Emissions and Disposal

9.1 Control, Treatment and Disposal

The PCP oil-borne pressure treatment process generates liquid and solid wastes and emissions to air. Numerous approaches are used or can be used by the industry to control, treat and/or dispose of the process wastes and emissions. Potential sources of chemical releases from PCP pressure treatment facilities are described in section 5.2 and Figure 1. Table 16 identifies the main categories of process wastes or emissions that can be generated at PCP facilities, and summarizes recommended control, treatment and/or disposal methods.

9.2 Waste Liquids Containing PCP

Liquid Process Wastes

Leaks and drips of oil solutions are contained and reused in the treatment process. Liquids such as condensates, washwaters and infiltrating waters, which cannot be reused, are treated to remove oil and PCP prior to discharge (38, 39, 40). The treatment techniques include one or a combination of:

- gravity separation;
- oil/water API separation, plate separation;
- activated sludge treatment;
- activated carbon treatment;
- physical-chemical treatment (i.e. flocculation);
- evaporation/condensation.

A regulatory discharge permit must be obtained for disposal of the treated aqueous wastes.

Table 16 Recommended Disposal Practices for PCP-Contaminated Wastes

Waste category	Examples	Recommendations
Liquid PCP/oil solutions	• Spilled PCP/oil concentrates • PCP work solutions • Drips from freshly treated lumber • Material skimmed from oil separators	• Collect and reuse.
Liquid PCP/water solutions	• Condensates • Washwaters • Infiltrating waters	• Treat to remove oil and PCP to within regulatory limits. • Dispose of treated waters as per regulatory requirements.
Contaminated solid wastes	• Debris and bottom sludge from storage tanks, sumps and pressure cylinders. • Soils contaminated by spills. • Cleanup absorbents. • Sludges from wastewater treatment processes. • Solid fire residues from PCP or PCP/oil storage areas. • Wrapping used for PCP blocks and bags. • Scraps, cuttings and shavings from PCP-treated lumber.	• Drain and/or drum, store and dispose of in accordance with provincial regulatory requirements (high-temperature thermal destruction appears to be the most feasible disposal option).
Miscellaneous solid wastes	• Empty containers and wrapping rinsed with alkaline water.	• Dispose of in sanitary landfills (subject to approval by the provincial regulatory agency).
Contaminated storm runoff	• Storm runoff or contaminated liquid discharges containing PCP require consultation with regulatory agency.	• Prevent or minimize contamination of storm runoff to greatest possible extent. • Monitor surface water discharges (in consultation with the provincial regulatory agency) to assess contaminant concentrations and determine the need for control.
Firefighting water runoff	• As above (contaminated storm runoff)	• Consider provisions for containment where PCP and PCP/oil solutions are present. • Consult with provincial regulatory agency to determine acceptable disposal practices.
Air	• Dust and vapours from unwrapping	• Provide local ventilation.
	• Vapours from cylinder door opening • Vapours from freshly treated charges	• Provide ventilation for worker safety.
	• Tank vent vapours • Vacuum exhaust	• Provide vapour traps for hot liquid tank vents and vacuum exhaust. • Vent tank vapours (cold storage) to outside as per the National Fire Code of Canada.
	• Evaporation of wastewaters	• Consult with provincial regulatory agency.
	• Open burning of sludges, debris	• Prohibit.

Contained Storm Runoff

Because PCP wood preservation facility sites are generally large, considerable volumes of storm runoff waters originate from these sites. Every precaution should be taken to avoid contamination of storm runoff water, particularly in the vicinity of PCP storage sites and the discharging and treatment areas. PCP chemical storage sites and treatment areas (i.e. pressure cylinders and associated equipment) should be roofed. Treated wood discharging areas should be paved, with provisions for collection of surface runoff. A possibility of PCP-contaminated runoff from treated wood storage areas must be acknowledged, and surface runoff from the storage areas should be monitored for chlorophenols and oil. If contamination is evident, and if the runoff is directed to a waterbody or a storm sewer, the need for control of the discharge will have to be determined in consultation with the appropriate regulatory agency.

Control Requirements

Control specifications will depend upon factors such as the volume and frequency of the discharge and the sensitivity of the receiving environment. The discharge of chlorophenol-contaminated emissions into waters inhabited by fish is subject to the federal *Fisheries Act*. Chlorophenol concentrations (total penta- and tetra-) in the order of 100 parts per billion are acutely lethal to fish (42).

9.3 Solids with Potentially High PCP Concentrations

For the purposes of this document, solids with “potentially high levels of PCP” are defined as:

- sludges from sumps, concentrate and work solution tanks, and pressure cylinders;
- sludges from wastewater treatment processes (e.g. flocculated materials);
- unwashed containers or wrappings for PCP blocks.

Pending the establishment of approved special waste disposal facilities in Canada, this document provides interim guidelines for the disposal of solid PCP wastes. These guidelines are subject to periodic review or change in light of the ongoing development of specific regulation in each province for managing hazardous wastes.

Guidelines for Disposal of Solid Wastes

While awaiting disposal, contaminated solids should be kept in leakproof containers in a specially designated area that is curbed and lined with impermeable material. The area should be roofed to protect the wastes from precipitation. Any seepage or leachate generated at the site should be contained.

The most feasible disposal option for chlorophenol wastes appears to be high-temperature thermal destruction. The U.S. Environmental Protection Agency standards for incineration of hazardous wastes can be used as a guideline to evaluate the suitability of this approach. These standards include (but are not limited to) the requirements for a minimum incineration temperature of 1000°C and a minimum residence time of two seconds. Such conditions have also been successfully used for destruction of dibenzofurans and dibenzodioxins (43).

9.4 Miscellaneous Solid Wastes

Miscellaneous solid wastes (e.g. wrappings or cuttings from PCP-treated lumber) from PCP wood preservation plants may be disposed of at designated sanitary landfills, as approved by the provincial regulatory agency.

9.5 Air Emissions

Air emissions at oil-borne PCP pressure treatment facilities are generally localized; effects, if any, would be restricted to workers at the facilities. Such emissions may include:

- dust and vapours from manual unwrapping of PCP blocks and emptying bags;
- vapours from tank vents;
- vapours from opening of retort cylinder doors;
- vapours from freshly treated charges;
- vapours from vacuum system outlets.

Design and procedural recommendations for control of localized emissions are suggested in sections 7 and 8.

10 Emission and Site Monitoring

Site monitoring and assessment are recommended at PCP facilities, in accordance with the design and operating objectives described in this document, to verify that wood preservative chemicals are properly managed at the site and to ensure environmental and worker health protection.

Environmental monitoring requirements should be developed. Consultation with provincial regulatory agencies and, where applicable, Environment Canada is advised. Similarly worker health monitoring programs should be developed, preferably in consultation with a provincial workers' compensation board and/or department of labour.

A program needs to ensure that adequate monitoring sites and frequencies are selected, and that the preservative constituents, detection levels and quality control are defined. The appropriate components of a site and worker exposure monitoring program are contained in Part I, Chapter A - General Background Information and Recommendations, Tables 14 and 15.

Analytical methodologies proposed for use must be approved by the regulatory agencies. In addition to PCP and its contaminants, constituents (analytes) for identification and quantification should include some indicators of petroleum oil contamination, for example, oil and grease analyses as per methods 503B or 503E in Standard Methods (44). Procedures for PCP quantification should recognize the existing state of the art (e.g. Jones [4]). All analytical data require documentation that will (a) trace the sample from the field to the final results, (b) describe the methodology used, (c) describe the confirmatory evidence, (d) support statements about detectability, (e) describe the quality assurance program and demonstrate adherence to it, and (f) support confidence statements for the data (45).

11 Transportation of PCP Oil Solvents and PCP Wastes

The transportation of PCP blocks, oil solvents and PCP wastes is regulated under the federal *Transportation of Dangerous Goods* (TDG) *Act*. The act does not apply to the transportation of treated wood or treated wood wastes. The regulation of intraprovincial movement of dangerous goods is a provincial responsibility.

The stipulated transportation procedures are abstracted in Part I, Chapter A - General Background Information and Recommendations, section 11.

12 Spill and Fire Contingency Planning

Preparedness for emergencies is essential in any wood preservation plant. Hence, facilities using PCP/oil should prepare and have readily available detailed contingency plans to ensure that response to spills and fires is quick, safe and effective.

12.1 Spill Contingency Planning

The recommendations outlined in section 12.1 of Part I, Chapter A - General Background Information and Recommendations apply to spill contingency plans for PCP/oil facilities.

12.2 Fire Contingency Planning

Although PCP is not flammable, work solutions of PCP and carrier oils are flammable. Extreme caution is to be exercised at fires involving PCP. If solid PCP is exposed to fire, or if combustion of PCP/oil mixtures occurs, the PCP will decompose, creating fumes containing hydrochloric acid and likely dioxins. All fire residues must be considered contaminated and must be contained for analysis and disposal as appropriate (see Table 16). It is, therefore, important for PCP wood preservation facilities to devise an adequate contingency plan for fire protection.

In addition to the recommendations in section 12.2 of Part I, Chapter A - General Background Information and Recommendations, the following recommendations should be contained in the fire contingency plan:

- ensure that PCP blocks and bags are stored in fire-protected areas;
- ensure that foam, dry chemical or carbon dioxide is used for oil fires.

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CHAPTER F

Pentachlorophenol Thermal (PCPT) Wood Preservation Facilities

Preservative-specific Information and Recommendations

This chapter must be used in conjunction with Part I, Chapter A - General Background Information and Recommendations.

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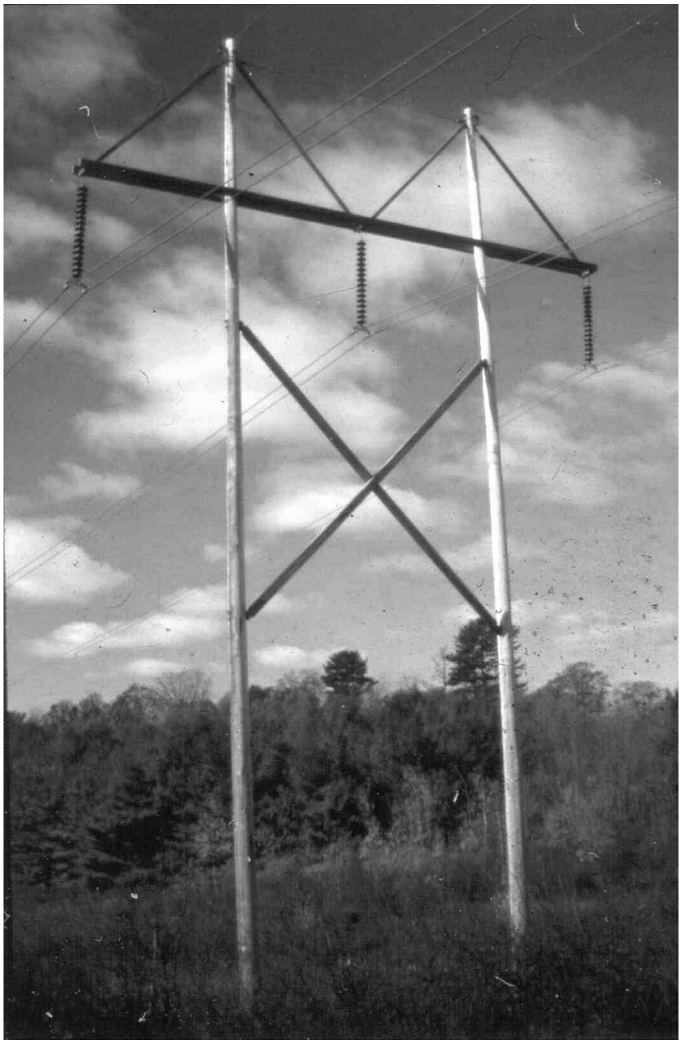
1 Production and Use



Pentachlorophenol[*] (PCP) was first used as a wood preservative in 1936 (1). The biological properties of PCP have resulted in its use as an antimicrobial agent in industrial cooling systems and papermaking, and as a fungicide in protein-based latex paints (2). Agriculture Canada restrictions in 1981 limited the use of PCP for preservation of outdoor wood products. The quantities for all wood preservation uses in 1992 were 1442 tons (3). No information seems to exist on the use of PCP for thermal treatments specifically. PCP use by the thermal process depends primarily on the size of the utility pole markets. PCP pressure treatments and chromated copper arsenate have partially replaced thermal PCP in the utility pole market. Table 1 provides an overview of the combined PCP usage at Canadian pressure and thermal treatment facilities.

PCP/oil mixtures are used for the thermal treatment of wood products such as telephone and electrical utility poles, as well as cross-arms. Thermal treatments for poles may be either full length or butt treatments only. The impregnated PCP is retained by the wood, and its bio-effectiveness protects the wood against fungi and insects. In addition to functioning as a carrier of PCP, the oil also provides extra protection against moisture content changes, providing more wood stability and resistance to splitting. For utility pole use, it has the additional advantage of providing resistance to electrical currents and facilitating the climbing of poles by line personnel.

PCP is prepared by reacting chlorine with phenol in the presence of a catalyst at high temperatures. PCP was last manufactured in Canada in 1983. It is now obtained from one of two U.S. manufacturers, who supply it in the form of solid blocks (907 kg/2000 lbs.) and bagged flakes (23 kg/50 lbs.). The petroleum oils used as carriers for PCP are purchased from Canadian sources. The oils must conform to standard CAN/CSA 080.201.

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[*] The technical product referred to as "PCP" in this document is not pure PCP. It contains 86% PCP and 10% "other chlorophenols and related products". Related products include trace amounts of some polychlorinated dibenzo-p-dioxins, chlorinated di-benzo-furans and hexachlorobenzene. Use of the term "PCP" in this document is consistent with industry nomenclature, and refers to the technical grade product.

Table 1 Overview of PCP Usage in Canada

Feature	Characteristics
Delivery format	907 kg (2000 lbs.) (solid blocks) 23 kg (50 lbs.) (flakes)
Concentration of active ingredients	Described by manufacturers as: “86% PCP, 10% other chlorophenols and related compounds and 4% inerts.”
Suppliers to Canadian facilities (1995)	• Vulcan Materials Co., Birmingham, • AL KMG-Bernuth Inc., Houston, TX
Estimated use by pressure and thermal treatment facilities (1992)	• 1 442 000 kg (3)
Concentration of work solutions	5% to 7% in petroleum oil
Typical preservative retention in treated wood	6.4- 12 kg PCP/m^3 treated wood (0.4-0.75 lbs./ft.^{3})
Major products treated in Canada	Utility poles and cross-arms

Table 2 Physical and Chemical Properties of PCP solids

Identification		
Common synonyms: (past and current) Chlorophen Cryptogyl O1 Dowicide 7 Dowicide G Penchlorol Penta PCP Santobrit Santophen 20 Witophen P	Manufacturers: • Vulcan Materials Co., Birmingham, AL • KMG-Bernuth Inc., Houston, TX	
Transportation and storage information		
Shipping state: Solids (blocks, flakes) Concentration: 96% by weight total (technical grade) chlorophenols (86% PCP) Classification: Poisonous	Storage temperature: Ambient Inert atmosphere: No requirement Venting: Open Containers/materials: Bags or solid blocks with polyethylene wrap	Labels and classification: Check with the Department of Transport
Physical and chemical properties		
Physical state: Solid Solubility: Freely soluble (oil) Slightly soluble in water 5 ppm by weight (0°C) 14 ppm by weight (20°C) 35 ppm by weight (50°C)	Floatability: Sinks in water Specific gravity: 1.98 (22°C) Vapour pressure: 0.00011 mm Hg (20°C) 40 mm Hg (211°C) Boiling point: Decomposes at 310°C Odour: Strong pungent odour when heated Vapour density: 9.2	Appearance: White to light brown solid Melting point: 188 to 191°C Flash point: Not flammable Explosive limits: Not flammable
Hazard data		
Fire *Extinguishing data*: Use water spray, dry chemical, foam or carbon dioxide. (Note: fire residues may contain chlorinated furans or dioxins and must be treated as contaminated.) Use water to cool fire-exposed containers. *Fire behaviour:* When heated to decomposition, toxic fumes of hydrogen chloride are formed. Chlorinated dioxins may be generated. *Ignition temperature*: Not combustible *Burning rate*: Not combustible	**Reactivity** *With water* : No reaction *With common materials*: Can cause rapid deterioration of rubber when dissolved in oil. *Stability*: Stable	

2 Physical and Chemical Properties

PCP is a solid at room temperature. It can be characterized as a stable organic compound, which is sparingly soluble in water and highly soluble in organic solvents. It adsorbs strongly to organic solids such as cellulose in wood.

PCP is chemically and biologically persistent in high concentrations (e.g. the 5-7% concentrations used for treatment of wood). Its persistence in treated wood and its toxicity to wood decay organisms are two major reasons for the use of PCP as a wood preservative.

Table 2 summarizes the physical and chemical properties of PCP (4, 5).

A more detailed account of the physical and chemical properties of PCP is presented in Part II, Chapter E, Pentachlorophenol Pressure (PCPP) Wood Preservation Facilities: Preservative-specific Information and Recommendations, section 2.

3 Environmental Effects and Human Concerns

A detailed account of environmental effects and human health effects is presented in Part II, Chapter E, Pentachlorophenol Pressure (PCPP) Wood Preservation Facilities: Preservative-specific Information and Recommendations, sections 3 and 4.

4 PCP Thermal Treatment Facilities

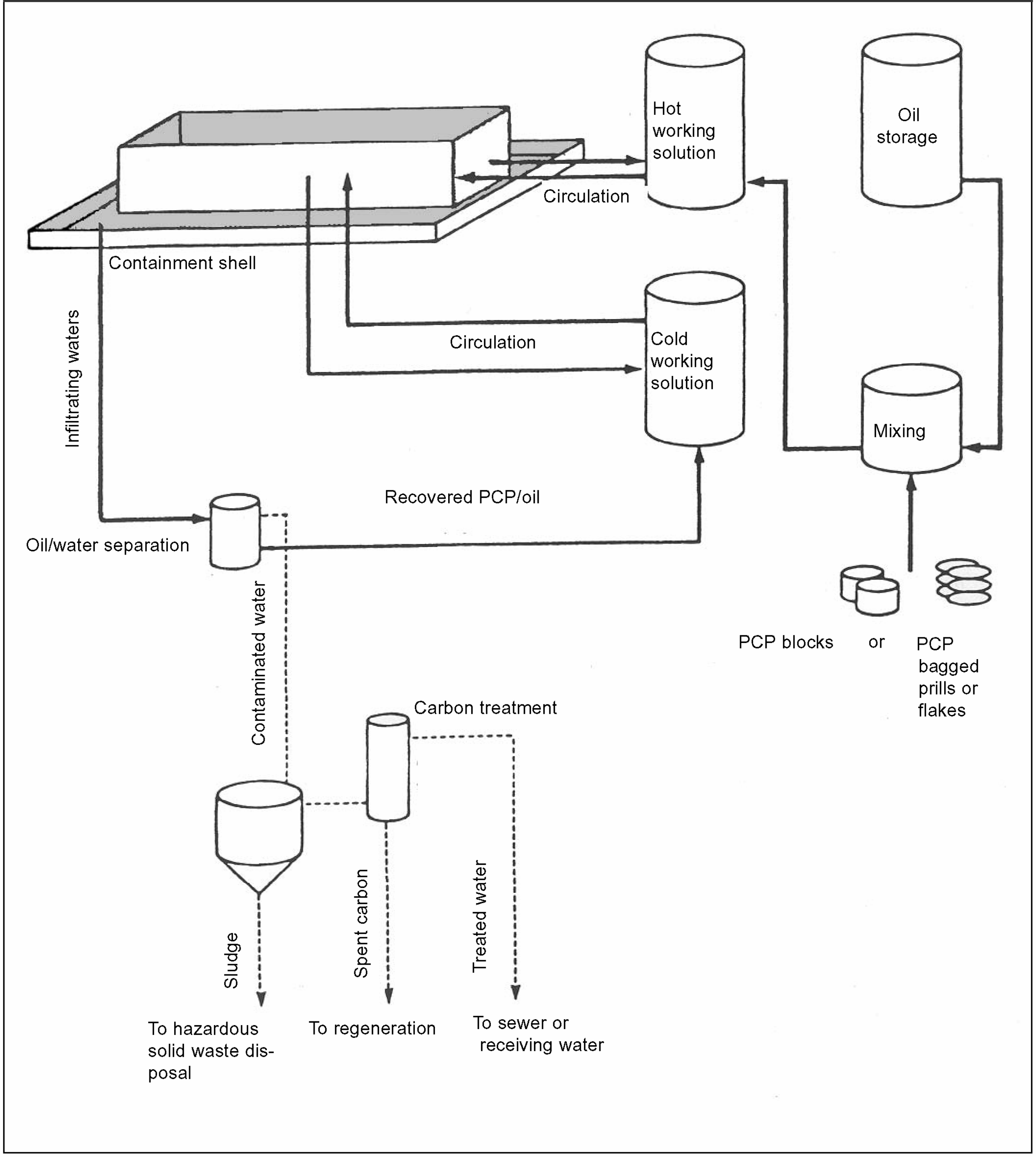
In 1993, three thermal treatment plants operated in Canada (3). The design and operational practices for control of PCP at thermal facilities varies. Newer facility designs reflect an increased awareness of the need for chemical control. Older facilities may compensate for design limitations through operational controls (6). Detailed design and operating practices are highly individualized.

4.1 Description of Process

PCP dissolved in oil is the only wood preservation chemical used at thermal treatment facilities in Canada. Discussions and recommendations in this document are therefore limited to the use of PCP in thermal operations, although the objectives would be applicable to any alternative wood preservative chemical, such as creosote, that may be used in the thermal process.

Thermal treatment (as shown in Figure 1) is used to achieve penetration and subsequent stabilization of the chemical agent within wood. The process can be used to treat entire lengths of timbers (e.g. poles) or only the ends of poles (butt treatment). The latter type of treatment would be used for the protection of only the portion of the utility pole that normally is placed below ground level.

Figure 1 Process Flow Diagram of PCP Thermal Treatment Plants



PCP is purchased in solid blocks (usually of 907 kg/2000 lbs.) or bags of flakes (usually of 23 kg/50 lbs.). Petroleum oils used as carriers for PCP are delivered by bulk truck or rail tanker and stored in tanks. Following delivery of PCP and the carrier oils, the following process steps occur.

Chemical Mixing

PCP blocks are lowered into a thermal treatment tank. Hot petroleum oil is circulated between the tank and a PCP/oil storage tank until a dissolved solution is attained. The prepared solution is then transferred to an insulated storage tank. The solution concentrations may range from 5% to 7% PCP.

Wood Preservation

Air seasoning is used to reduce moisture in wood in preparation for thermal treatments. Prior to treatment, the wood products may be incised and shaped to end-user specifications. Poles are the most common thermally treated product, although cross-arms may also be treated by this process (7). The poles are loaded into horizontal, rectangular tanks for full-length treatment, or into cylindrical tanks for upright butt treatment of pole ends, using cranes or custom forklift equipment. Poles placed in the horizontal full-length tanks are held in place by steel cross-beams. Full-length tanks are normally covered with plywood or steel lids prior to application of the preservative. Typical dimensions of such tanks are 4 m x 4 m x 30.5 m.

Preservative Application

Thermal treatment is analogous to the full-cell pressure treatment process. The treatment cycle basically consists of a hot and cold bath as described in section 2.2.2 (Preservation Processes) of Part I, Chapter A - General Background Information and Recommendations. After the impregnation cycle is completed, the poles are left in the treatment tanks to cool and to allow any excess preservative to drip off. They are then inspected and sampled for quality control purposes.

For butt treatments, the wood is held vertically with only a portion of the pole submerged in oil. The impregnation cycles are similar to the full-length thermal cycles. Butt dip tanks are difficult to cover during treatment. However, the exposed oil surface area is limited.

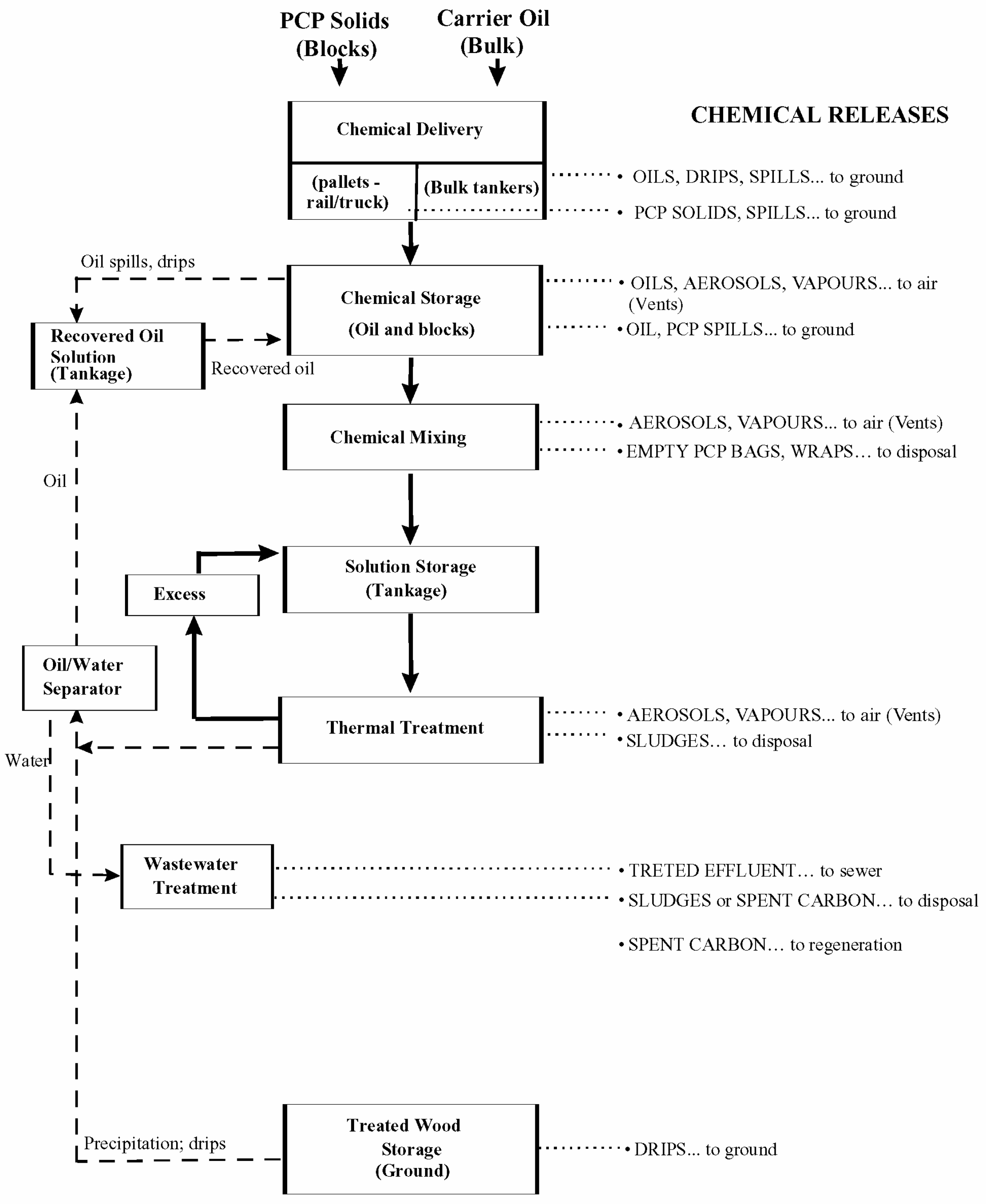
Storage of Treated Product

The cooled, treated wood is moved from the treatment tank to a drip pad, then a storage area, or is loaded directly into railcars or trucks for shipment.

4.2 Potential Chemical Discharges

Thermal wood preservation facility design and operational practices vary (8, 9, 10), and each facility has potential sources of emissions that may affect worker health and/or the environment. The potential sources and releases are illustrated in Figure 2.

Figure 2 Potential Chemical Releases from PCP Thermal Treatment Plants



Liquid Discharges

Although no liquid process wastes are produced during thermal treatment, the following situations could create liquid releases:

- spills or overflows of liquid from open treatment tanks;
- infiltration of groundwater into tank containment systems;
- leaks from treatment tanks that have no containment provisions;
- surface runoff from the treated wood storage areas.

The need for control of runoff waters depends on analytical and/or bioassay evaluations and on regulatory requirements.

Solid Wastes

Solid wastes from oil-borne PCP thermal treatment facilities may include:

- sludges from treatment and storage tanks, in particular the "cold" PCP/oil storage tank;
- sludges from wastewater treatment processes (e.g. flocculated material);
- pallets and wrappings from bulk PCP.

Air Emissions

Air emissions from thermal treatment facilities are localized and intermittent, and may include:

- vapours that escape from the treatment tanks during the treatment cycle;
- vapours from tank vents;
- vapours from the PCP block storage;
- vapours from freshly treated charges.

Emissions that could disperse beyond facility boundaries include:

- vapours from uncovered treatment tanks during the treatment cycle.

4.3 Potential Effects of Chemical Discharges

The actual impact of any chemical on the environment depends upon many factors, including the location of the wood preservation facility relative to ground or surface waters, the species of aquatic biota in adjacent surface waters, and the amount of

preservative released. Variables that can influence effects on worker health include ambient concentrations, frequency of exposure and protective measures during the time(s) of exposure.

All thermal facilities have a potential to affect the environment, as do any other chemical-using industrial facilities, if proper control measures are not in place. Documented PCP releases from wood preservation facilities have been due to either poor design or poor operating practices. The effects of these releases appear to be either localized within the plant site (i.e. soil and groundwater contamination) or in the environment immediately adjacent to the plant site.

Fires that have occurred at Canadian PCP thermal facilities illustrate the need for proper contingency planning for fire control and for containment of oil solutions and fire runoff waters.

Human health could be affected if proper precautions are not taken during handling of PCP, exposure to minor spills and residues in working areas, exposure to vapours or handling of treated products.

5 Personnel Protection

With the use of PCP, it is important that protection be provided for all potential types of exposure: eye contact, skin contact and inhalation. Many work situations require protection against more than one type of exposure, for example, when chlorophenol dusts, aerosols or vapours are produced. In these situations, the use of nose-mouth respirators that do not cover the eyes and skin around eyes may lead to a false sense of security. Full face shields or full-face cartridge respirators are required.

5.1 First Aid

The first aid measures described in Part II. Chapter E, Pentachlorophenol Pressure (PCPP) Wood Preservation Facilities: Preservative-specific Information and Recommendations, section 6.1 apply here as well.

5.2 Regulatory Controls

The regulatory controls described in Part II, Chapter E, Pentachlorophenol Pressure (PCPP) Wood Preservation Facilities: Preservative-specific Information and Recommendations, section 6.2 apply here as well.

5.3 *Safety Precautions During Operation*

Table 3 Safety Precautions for Personnel Working with PCP Solutions

Objective: To ensure safe workplace practices for each activity during the treatment process.	
Activity	**Recommendations**
Unloading PCP solids	• Wear protective apparel including chemical goggles or face shields, impermeable gauntlets, coveralls, impermeable aprons and impermeable shoes or boots. (Resistance rating of materials: Excellent — viton, neoprene, butyl rubber; Good — nitrile, polyvinyl chloride (PVC); Fair — polyvinyl alcohol, polyethylene.) • Do not wear contact lenses. • Work in well-ventilated areas. • Approved respirators should be readily available. Wear respirators whenever exposure to dust can occur. • Provide an emergency eyewash and shower in the immediate unloading or handling areas. • Provide adequate equipment for safe, controlled handling of blocks and as appropriate for the specific facility. • Do not drop blocks or intentionally breakup. • Immediately vacuum PCP chips or spilled solids (vacuums should have effectively filtered exhausts).
Preparing PCP work solutions	• Work in a well-ventilated area. • Provide an emergency eyewash and shower in the immediate area. • Wear full face protection, organic solvent-impermeable gauntlets, coveralls, aprons and shoes or boots for all operations involving handling of PCP solids. • In addition, wear an approved full facepiece respirator whenever dust conditions occur. Respirator cartridges must be NIOSH-rated for protection from “pesticides and organic vapors and dusts.” • Thoroughly vacuum PCP dust and solids from the work area following solution preparation. • Dispose of empty PCP wraps and PCP-contaminated debris according to Table 13. • Thoroughly clean protective equipment after use.
Sampling procedures	• Wear eye protection and gloves impermeable to organic solvents when sampling PCP solutions. • Wear impermeable gloves when taking borings from freshly treated wood. • Clean gauntlets and goggles as soon as possible after completing sampling. • Clean the outside of sample containers after sampling solutions. • Wash hands thoroughly after all sampling operations.

Table 3 Safety Precautions for Personnel Working with PCP Solutions (continued)

Activity	Recommendations
Cleaning treatment or storage tanks	• Follow all standard precautions for vessel entry (as per provincial health and safety regulations). • Flush vessels as required to establish safe entry conditions, or use an approved self-contained breathing apparatus prior to entry. • Wear NIOSH-approved respirators (or breathing apparatus as above), organic solvent impermeable gauntlets, outer clothing and boots during all vessel entries. • Always have a standby attendant present and provision for continuous outside communications. • Collect and store contaminated waste material in sealed and labelled drums. • Wash all protective equipment immediately after use. • Shower after completion of cleanup tasks.
Removing treated charges from tanks	• Wear eye protection and organic solvent-impermeable gauntlets and coveralls or apron when manually handling slings for charge removal. • Avoid breathing preservative mists. Wear an approved respirator if airborne concentrations are unknown or at or above TLVs.*
Handling treated lumber	• Wear impermeable gloves, apron and boots if handling treated wood manually. • Wear a respirator if treated wood is handled in enclosed areas (e.g. boxcars). • Change coveralls daily.
Handling and maintaining contaminated equipment	• Thoroughly steam-clean or flush contaminated equipment with solvent (e.g. Varsol or equivalent) prior to handling. (Contain all solvent washings.) • Change coveralls daily. • Wear impermeable apron, gloves and boots.
Welding	Welding can produce toxic fumes. In addition to the precautions for handling and maintaining contaminated equipment: • Obtain the specific approval of the plant supervisor before welding. • Block or disconnect lines from tanks before initiating welding operations. • Completely drain and thoroughly rinse tanks or lines prior to welding operations. • Ensure that equipment is completely dry from cleaning solvent residues. • Wear a respirator or provide effective, local exhaust ventilation during welding to prevent potential exposure to toxic fumes. • Assure good general ventilation of the work area. • Comply with all additional provincial workplace safety rules.

NIOSH = National Institute for Occupational Safety and Health.
TLV = threshold limit value.

* An initial workplace monitoring program will have determined the need for respirator use. The results of the program are assumed to be indicative of conditions in subsequent facility operations, unless procedural or design changes have occurred.

6 Design Recommendations

Tables 4 to 9 present good design features, specifically applicable to PCP thermal wood preservation facilities. The recommendations made here must be used in conjunction with the basic design criteria listed in Part I, Chapter A - General Background Information and Recommendations, section 7.

Table 4 Recommended Design Features for Chemical Delivery Areas

(See also Part I, Chapter A - General Background Information and Recommendations, Table 3.)

Delivery format	Design feature	Recommendations
Bulk liquid • Petroleum oil (CSA 080.201) (delivered by truck or rail tanker)	**Objective:** To provide an off-loading area that enhances spill prevention and containment and complies with section 4 of the NFCC.	
	Off-loading pad	• Provide a graded loading site or sloped floor (preferably an impervious pad) to divert spills, or provide non-combustible sills, curbs or dykes; drain to a containment area in accordance with the NFCC.
	Drip control	• Design, install and maintain system to prevent leakage and spillage as per the NFCC.
	Delivery system piping	• Install piping and piping systems in accordance with specifications outlined in the NFCC, i.e. materials, corrosion protection, identification, joints, location and arrangement of pipes, valves, heating, methods of transfer and operating procedures. • Protect delivery systems if there is potential for vehicular impact or physical damage.
	Static protection	• Install acceptable provisions for electric bonding as per the NFCC.
	Backflow prevention	• Install backflow preventers on delivery lines.
PCP • Solid blocks, bags	**Objective:** To provide an off-loading area that promotes spill prevention and provides containment for and facilitates cleanup of spilled material.	
	Off-loading area/shelter	• Provide a dry, paved off-loading area with protection from the weather, preferably near the storage area.
	Containment	• Provide for containment of the worst event spill of PCP solids (e.g. from dropped pallet load).
	Area cleanup	• Provide a vacuum cleaner system (with filtered exhaust) for cleanup of solids spilled during unloading and transfer operations.

NFCC = National Fire Code of Canada.

Table 5 Recommended Design Features for Chemical Storage Areas

(See also Part I, Chapter A - General Background Information and Recommendations, Table 4.)

Storage format	Design	Recommendations
Bulk liquids • Petroleum oil (CSA 080.201) • PCP/oil working solutions • Drip return	**Objectives:** ◊ To provide positive spill prevention features. ◊ To conform to section 4.3 of the NFCC, where applicable.	
	Tanks	• Engineer materials of construction and dimensions in accordance with ASME, CAN and API standards as defined in the NFCC. • Mount tanks on containment pad surfaces within a dyked area (subsurface storage tanks are strongly discouraged). • Mount tanks in stable position and anchor securely. • Locate tanks in accordance with the NFCC (i.e. minimum distances from buildings and other tanks). • Evaluate means of controlling contaminated surface waters (e.g. roofing of tanks, runoff water treatment). • Test for leakage prior to backfilling as per the NFCC. • Provide grounding for tanks as per the NFCC. • Provide vent piping for vapour control as per the NFCC.
	Spill containment	• Provide structurally sound and impermeable dykes as per the NFCC. • Provide a dyked containment volume equivalent to 110% of a single storage tank or vessel within the dyked area or equivalent to 110% of the volume of the largest tank plus 10% of the aggregate volume of the remaining tanks for multiple tanks within a containment area. • Provide for directing all spills, washes and infiltrating water to tankage as per NFCC. (Contaminated liquids must be treated to applicable limit before discharge) • Provide surface drainage to prevent pooling of minor spills and washdowns as per the NFCC.
	Piping and valves	• Design according to applicable codes (e.g. NFCC).
	Spill prevention/detection	• Install devices to prevent overflow from tanks as per the NFCC, preferably reliable, independent high-level alarms on tanks (i.e. audible alarms).
	Location	• The preferred location for oil tankage (all solutions) is in an exterior centralized tank farm area that is arranged in accordance with the NFCC.
	Security	• Provide security precautions to prevent vandalism or access to tanks by unauthorized persons (the NFCC requires a firmly anchored fence surrounding bulk storage tanks if their aggregate capacity exceeds 564 000 L).

Table 5 Recommended Design Features for Chemical Storage Areas (continued)

Storage format	Design feature	Recommendations
PCP • Solid blocks, bags	**Objective:** To provide sheltered, secure, fire-protected storage of PCP solids.	
	Location	• Provide safe, easy access to the mixing area (design to contain and facilitate cleanup of PCP dust/chips lost during transit to the mixing area).
	Shelter	• Provide storage in an enclosed roofed, secure area, segregated from other chemicals (design to prevent infiltrating precipitation). • Design to prevent fire in PCP storage areas (use of non-combustible construction materials is preferred).
	Ventilation	• Provide adequate ventilation for both routine operation and emergency situations.
	Containment/cleanup	• Store PCP in a paved, curbed or dyked area with no floor drains (or with effective, positive blocks for drains). • Design surfaces for effective cleanup of spilled material. • Provide a vacuum cleaner system (with filtered exhaust) for cleanup of solids spilled during unloading and transfer operations.
	Security	• Provide effective security against unauthorized access.
	Emergency response	• Provide appropriate measures for rapid, effective fire control with containment of liquid firefighting residues and treatment to required limits before discharge.
• Bulk sludges	Location/shelter	• Locate storage in an exterior or well-ventilated location.
	Containment	• Provide closed tanks in sound condition. • Install tanks in a containment area with impermeable, cleanable floors. • Provide adequate containment capacity for the worst event spill. • Block any drains in the containment area; design to collect infiltrating precipitation for treatment to applicable limits prior to discharge (if contaminated).
	Handling	• Provide transfer equipment for clean, safe sludge handling with minimum worker exposure.
	Security	• Provide effective security against unauthorized access and/or release of tank contents.

NFCC = National Fire Code of Canada.

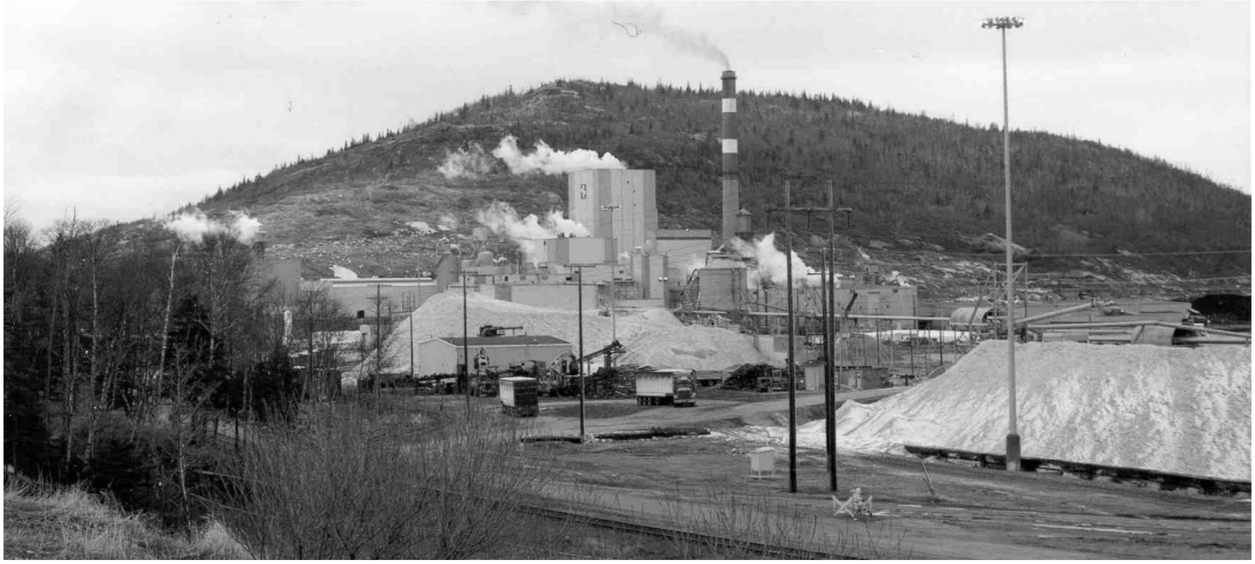


Table 6 Recommended Design Feature for Chemical Mixing Systems

Chemical form	Design feature	Recommendations
PCP Blocks, flakes	**Objectives:** ◊ To provide a mixing system with effective spill-prevention features. ◊ To provide a mixing system that minimizes worker contact with PCP.	
	Configuration	• Mixing by placing PCP in a closed tank is the preferred method.
	Solids handling	• Provide appropriate equipment for safe, controlled lifting and handling of PCP blocks. • Provide a dry, paved area for plastic wrap removal from blocks and de-bagging of flakes. • Provide a vacuum cleaner system (filtered exhaust) for effective cleanup of PCP dust and chips from handling/transfer operations.
	Spill containment	• Provide all applicable features for “spill containment of bulk liquids” (see Table 5).
	Splash protection	• Discourage open transfer operations. If unavoidable, provide reliable splash protection.
	Emergency response	• Provide features described in “Emergency response” (see Table 5).

Table 7 Recommended Design Features for Treatment Process Systems: General Recommendations

Design feature	Recommendations
Objectives: ◊ To minimize and contain all releases of PCP. ◊ To conform with the NFCC.	
Shelter, configuration	• Use exterior treatment tank. • Locate other process equipment and systems in a centralized area. • Provide heated (where necessary) enclosure for process controls with any air emissions vented externally.
Tanks, piping and valves	• Provide all spill containment precautions as outlined in Table 5. • Engineer system to promote containment and isolation of preservative chemical. • Review section 4 of the NFCC to determine compliance of the system with the NFCC. • Provide effective access and containment for all subsurface tanks and piping. • Avoid installation of subsurface tanks and piping, particularly in areas with high groundwater levels.
Process emissions to air	• Locate treatment tanks to minimize downwind effects either to yard workers or to adjacent properties actively used for residential/commercial purposes. • Install any control equipment as necessary to comply with applicable emission limits. • Cover solutions in tanks during process cycle.
Process control area	• Locate the process control area for maximum visibility of treatment system.
Fire controls	• Provide fire controls as described on site-specific basis in consultation with the local fire department. Firefighting residues may contain toxic products of PCP combustion. • Provide containment for contaminated runoff waters and residues generated by firefighting activities (e.g. blockage of storm drains, adjacent ditches).
Weather protection (winter operations)	• Protect equipment from freezing, particularly where water is or may be present (e.g. water may build up in the bottom valves of the oil transfer system). • Winterize process control area.

Table 8 Recommended Design Features for Components of Treatment Process Systems

Design feature	Recommendations
Objectives: ◊ To provide fail-safe operation of the treatment system. ◊ To minimize the potential for PCP spills.	
Treating tanks	• Engineer treatment tanks for long-term integrity. • Assure tanks are secured to prevent uplifting. • Provide secondary containment vessel or other impermeable containment around treatment tanks. • Install an effective protection device to prevent overfilling of treatment tanks with preservative: – Install independent overflow indication/alarm/pump interlocks between the treating tanks and the control point (where the tank is not visible from the control point). – Provide containment for collection and direct return of tank overflow. – Construct overflow connection as per the NFCC. • Provide corrosion protection of underground steel tanks as per the NFCC. • Provide for tank lids or roofing to reduce vapour emissions and to reduce/prevent rainfall/snowfall into tanks: Construct lids as per the NFCC. • Provide walkway grates (or alternative design) to prevent worker contact or tracking of chemicals. • Provide guard rails and other safety measures as required by provincial authorities for operations near open tanks. • Provide means to contain frothing and/or overflows.
Piping and recycle systems	• Design an overall system that is effective at containing and recycling all chemicals, with minimum potential for release and dispersal and minimum infiltration of water. • Select and install piping as per Table 5.
Process controls	• Design for simple, unambiguous operation (regardless of the degree of automation). • Establish a clear relationship between process controls and process functions in order to minimize operator error (e.g. provide flow diagrams for process).

NFCC = National Fire Code of Canada.

Table 9 Recommended Design Features for Treated Wood Storage Areas

Design feature	Recommendations
Objectives: ◊ To minimize losses* of preservative chemicals from treated wood by: – providing proper conditions for containing drips from freshly treated wood, – controlling the generation and disposal of contaminated runoff waters. ◊ To comply with the National Fire Code of Canada.	
General design	• Integrate consideration of design provisions for: – impermeable drip pad for freshly treated wood, – efficient drip and runoff collection and containment from drip pad, – efficient and safe movement of treated wood.
Storage areas	• Locate storage areas away from surface waterbodies. • Routinely monitor containment levels in storage area runoff. – Make provision for collecting and treating storm runoff if unacceptable levels of contamination occur.

* The nature and magnitude of drippage losses depend strongly on oil and wood types and on process-specific factors.

Table 10 Recommended Operating Practices for Chemical Handling and Storage

Operation	Recommendations
Unloading chemicals	**Objective:** To assure that unloading of treatment chemicals occurs in a safe manner (as per section 4 of the NFCC).
• PCP solids • Petroleum oil	• Assure that personnel engaged in transfer of petroleum oil and PCP are trained as per the NFCC, i.e. emergency procedures, constant attendance during unloading, operation of fire protection equipment and emergency shutoff valves. • Consult with section 4 of the NFCC regarding transfer operations of combustible materials via different modes of transport, e.g. rail, truck, ship unloading procedures, grounding, etc
Handling of wood preservation chemicals • PCP blocks, flakes	• Store empty PCP wrappings and dispose of as contaminated wastes in accordance with section 8. • Contain all spilled PCP solids (dust; chips) and reuse or dispose of as contaminated solid waste.
Storage of wood preservation chemicals • PCP solids • Petroleum oil	• Implement visual inspection routine at least once each shift for prompt detection of abnormal conditions (as per the NFCC). • Frequently inspect and test all safety shutoff valves and other fire safety devices (as per the NFCC).

NFCC = National Fire Code of Canada.

7 Operational Recommendations

The recommendations for good operating practices listed in Tables 10 to 12 must be used in conjunction with those in Part I, Chapter A - General Background Information and Recommendations, section 8. They are meant to protect both workers and the environment from harmful exposure to PCP and its solutions.

Table 11 Recommended Operating Practices for Process Systems

Operation	Recommendations	
Routine checks	**Objectives:** ◊ To define practices to enhance environmental protection and worker safety. ◊ To comply with the NFCC	
	All process components	• Visually check the complete system for leaks as per the NFCC.
	Charges	• Secure loads to avoid uncontrolled floating. • Stack loads to allow good drainage of preservative from all surfaces after treatment.
	Treating tank lids	• Place tight-fitting lids on tanks to minimize the release of vapours.
Post-treating checks	**Objective:** To prevent worker contact with treatment solution and with freshly charged loads.	
	Quality control or load removal problems (entry into treatment tanks)	• Do not enter treating tanks until the tank has cooled. – If tank TLV levels are unknown, or at or above regulatory TLV levels, the attendant must wear a self-contained full-face respiratory mask, disposable coveralls, impermeable boots and gauntlets. • If TLV levels are less than regulatory limits, wear an approved respirator, disposable coveralls, impermeable boots and gauntlets. • Assure presence of a standby attendant. • Shower immediately after tank entry. • Wear impermeable gloves when sampling treated wood.
	Charge removal	• Allow ventilation of the charge before unloading by exposing the open tank to air. • Minimize exposure to vapours by working upwind of the charge and/or wearing an approved respirator. • Wear impervious gauntlets during handling of freshly treated charges. • Maximize use of mechanical equipment for charge removal to minimize the need for worker handling of freshly treated wood. • Remove charges from tank only when preservative drippage has stopped.

NFCC = National Fire Code of Canada.
TLV = threshold limit value.

Table 12 Recommended Operating Pratices for Maintenance, Cleanout and Shutdown of Treatment Systems

Operation	Recommendations
Equipment maintenance	• Check integrity of subsurface thermal tanks (e.g. by sandblasting tanks) at least once every 2 years (cracks will be visible in cleaned tanks).
Cleanout	**Objectives:** ◊ To prevent accumulation of PCP solutions and sludges within the treatment systems. ◊ To assure worker safety during cleanout operations.
	• Observe personnel safety precautions during all procedures (Table 3). • Routinely inspect sludge levels in storage and mix tanks and clean out if necessary. Determine and specify sludge levels that require removal in consultation with qualified technical personnel. – During cleanup, inspect gauge floats. • Routinely inspect treating tanks for sludge accumulation and clean out if necessary. • Thoroughly cool tanks prior to entry : – If airborne concentrations are unknown, at, or above TLVs, attendant must wear self-contained breathing apparatus, impermeable gloves, boots and coveralls. – If airborne concentrations are below TLVs, attendant must wear approved respirators, impermeable gloves, boots and coveralls. – Provide a constant standby attendant and continuous outside communication. – Follow standard safety procedures for entry of confined spaces. – Prevent skin contact with sludges. – Remove sludges with equipment used only for facility-related purposes. – Collect, drain and store contaminated material in sealed drums pending disposal (Table 13). – The attendant should shower immediately after cleaning retorts or tanks. – Thoroughly clean (e.g. by sandblasting) treatment tank interiors (suggested biannually) to facilitate the inspection for structural integrity.
Alarms	• Test all alarms and safety devices regularly (or as specified by manufacturer).

TLV = threshold limit value.

8 Process Emissions and Disposal

8.1 Control, Treatment and Disposal

The PCP oil-borne thermal treatment process generates solid wastes and emissions to air. No liquid process wastewaters per se are generated. Numerous approaches are used or can be used by the industry to control, treat and/or dispose of the process wastes and emissions. Potential sources of chemical releases from PCP thermal treatment facilities are described in section 4.2 and Figure 2. Table 13 identifies the main categories of process wastes or emissions that can be generated at PCP facilities, and summarizes recommended control, treatment and/or disposal methods.

8.2 Handling of Waste Liquids Containing PCP

Liquid Process Wastes

Leaks and drips of oil solutions generally do not occur during the thermal treatment of wood. Frothing and/or overflow from the treatment tank can occur. The thermal tank should be designed to accommodate containment of such overflow. Structural defects in the treatment tank can also result in releases of oil solutions to groundwater. Containment shells are required to prevent groundwater contamination. Contaminated water solutions may be generated, such as washwaters and waters that infiltrate subgrade containment shells. Oil and PCP must be removed from these wastewaters prior to discharge (8, 9, 10). The techniques may include one or a combination of:

- oil/water separation;
- activated sludge treatment;
- activated carbon treatment;
- physical-chemical treatment (i.e. flocculation).

A regulatory discharge permit must be obtained for disposal of the treated aqueous wastes.

Contaminated Storm Runoff

Because thermal treatment facility sites are generally large, considerable volumes of storm runoff waters occur from these sites. Every precaution should be taken to avoid contamination of storm runoff water, particularly in the vicinity of PCP storage sites and treatment areas. A possibility of PCP-contaminated runoff from treated wood storage areas must be acknowledged; surface runoff from the storage areas should be monitored for chlorophenols and oil. If contamination is evident, and if the runoff is directed to a waterbody or a storm sewer, the need for control of the discharge will have to be determined in consultation with the appropriate regulatory agency.

Table 13 Recommended Disposal Practices for PCP-Contaminated Wastes

Waste category	Examples	Recommendations
Liquid PCP/oil solutions	• Spilled PCP/oil concentrates • PCP work solutions • Drips from freshly treated lumber • Material skimmed from oil separators	• Collect and reuse.
Liquid PCP/water solutions	• Washwaters • Infiltrating waters	• Treat to remove oil and PCP to within regulatory limits. • Dispose of treated waters as per regulatory requirements.
Contaminated solid wastes	• Debris and bottom sludge from storage tanks, sumps and thermal tanks. • Soils contaminated by spills. • Cleanup absorbents. • Sludges from wastewater treatment processes. • Solid fire residues from PCP or PCP/oil storage areas. • Wrapping used for PCP blocks and bags. • Scraps, cuttings and shavings from PCP- treated lumber.	• Drain and/or drum, store and dispose of in accordance with provincial regulations (high-temperature thermal destruction appears to be the most feasible disposal option).
Miscellaneous solid wastes	• Empty containers and wrapping rinsed with alkaline water	• Dispose of in sanitary landfills (subject to approval by the provincial regulatory agency).
Contaminated storm runoff	• Storm runoff or contaminated liquid discharge containing PCP at concentrations exceeding discharge limits or that is determined to be toxic to fish at point of discharge (toxicity is determined by bioassay tests)	• Prevent or minimize contamination of storm runoff to greatest possible extent. • Monitor surface water discharges (in consultation with the provincial regulatory agency) to assess contaminant concentrations and determine the need for control.
Firefighting water runoff	• As above (contaminated storm runoff)	• Consider provisions for containment where PCP and PCP/oil solutions are present. • Consult with provincial regulatory agency to determine acceptable disposal practices.

Table 13 Recommended Disposal Practices for PCP-Contaminated Wastes (continued)

Waste category	Examples	Recommendations
Air	• Dust from unwrapping	• Provide local ventilation.
	• Vapours from thermal tank during the hot oil treatment process • Vapours from freshly treated charges	• Use tank covers during process. • Provide respiratory equipment for workers.
	• Tank vent vapours	• Provide vapour traps for hot liquid tank vents and vacuum exhaust. • Vent tank vapours (cold storage) to outside as per the National Fire Code of Canada.
	• Evaporation of wastewaters	• Consult with provincial regulatory agency.
	• Open burning of sludges, debris	• Prohibit.

Control Requirements

Control specifications will depend upon factors such as the volume and frequency of the discharge and the sensitivity of the receiving environment. The discharge of chlorophenol-contaminated emissions into waters inhabited by fish is subject to the federal *Fisheries Act*.

8.3 Disposal of Solids with Potentially High PCP Concentrations

For the purposes of this document, solids with potentially high levels of PCP are defined as:

- sludges from work solution tanks and treatment tanks;
- sludges from wastewater treatment processes (e.g. flocculated materials);
- unwashed containers or wrappings for PCP.

Sludges from thermal tanks constitute most of the solid wastes at thermal facilities. Operating and design modifications can be used to significantly reduce the volume of sludge. For example, open exposure of the tanks to precipitation leads to the generation of higher volumes of sludge. Roofing could eliminate this source of contamination.

Pending the establishment of approved special waste disposal facilities in Canada, this document provides interim guidelines for the disposal of solid PCP wastes. These guidelines are subject to periodic review or change in light of the ongoing development of specific regulations in each province for managing hazardous wastes.

Guidelines for Disposal of Solid Wastes

While awaiting disposal, the contaminated solids should be in leakproof containers in a specially designed area that is curbed and lined with impermeable material. The area should be roofed to protect the wastes from precipitation. Any seepage or leachate generated at the site should be contained.

The most feasible disposal option for chlorophenol wastes appears to be high-temperature thermal destruction. Regulatory agencies should consider specific requests to incinerate chlorophenol-containing wastes on a case-by-case basis. The U.S. Environmental Protection Agency standards for incineration of hazardous wastes can be used as a guideline to evaluate the suitability of these requests. These standards include (but are not limited to) requirements for a minimum incineration temperature of 1000°C and a minimum residence time of two seconds. Such conditions have also been successfully used for destruction of dibenzofurans and dibenzodioxins (12). Siting of the incinerator must also be taken into account.

Incineration of PCP-contaminated solids will require the specific approval of the appropriate provincial agency.

8.4 Disposal of Miscellaneous Solid Wastes

Miscellaneous solid wastes (e.g. wrappings, empty pallets or drums rinsed with alkaline solution, cuttings from PCP-treated lumber) from PCP wood preservation plants may be disposed of at designated sanitary landfills as approved by the municipality and/or provincial regulatory agency.

8.5 Control of Air Emissions

Air emissions at thermal treatment facilities are generally localized; effects, if any, would be restricted to workers at the facilities. Such emissions may include:

- vapour from thermal tanks during the hot oil treatment process;
- dust from manual unwrapping;
- vapours from tank vents;
- vapours from freshly treated charges.

Design and procedural recommendations for control of these localized emissions are suggested in sections 6 and 7.

9 Emissions and Site Monitoring

Site monitoring and assessment are recommended at PCP thermal facilities, in accordance with the design and operating objectives described in this document, to verify that wood preservative chemicals are properly managed at the site and to ensure environmental and worker health protection

Environmental monitoring requirements may normally be developed in consultation with provincial regulatory agencies and, where applicable, Environment Canada, whereas worker health monitoring programs may be developed in consultation with a provincial workers' compensation board and/or department of labour.

A program needs to ensure that adequate monitoring sites and frequencies are selected and that the preservative constituents, detection levels and quality control are defined. The appropriate components of a site and worker exposure monitoring program are contained in Part I, Chapter A - General Background Information and Recommendations, Tables 14 and 15.

Analytical methodologies proposed for use must be approved by the regulatory agencies. In addition to PCP, constituents (analytes) for identification and quantification should include some indicators of petroleum oil contamination, for example, oil and grease analyses as per methods 503 B or 503 E in Standard Methods (13). Procedures for PCP quantification should recognize the existing state of the art (e.g. Jones [2]). All analytical data require documentation that will (a) trace the sample from the field to the final results, (b) describe the methodology used, (c) describe the confirmatory evidence, (d) support statements about detectability, (e) describe the quality assurance program and demonstrate adherence to it, and (f) support confidence statements for the data (14).

10 Transportation of PCP Oil Solvents and PCP Wastes

The transportation of solid PCP, oil solvents and PCP wastes is regulated under the federal *Transportation of Dangerous Goods* (TDG) *Act*. The act does not apply to the transportation of treated wood or treated wood waste. The regulation of intraprovincial movement of dangerous goods is a provincial responsibility.

The stipulated transportation procedures are abstracted in Part I, Chapter A - General Background Information and Recommendations, section 11.

11 Spill and Fire Contingency Planning

Preparedness for emergencies is essential in any wood preservation plant. Hence, facilities using PCP/oil should prepare and have readily available detailed contingency plans to ensure that response to spills and fires is quick, safe and effective.

11.1 Spill Contingency Planning

The recommendations outlined in section 12.1 of Part I, Chapter A - General Background Information and Recommendations apply to spill contingency plans for PCP/oil facilities.

11.2 Fire Contingency Planning

Although PCP is not flammable, work solutions of PCP and carrier oils are flammable. Extreme caution is to be exercised at fires involving PCP. If solid PCP is exposed to fire, or if combustion of PCP/oil mixtures occurs, the PCP will decompose, creating fumes containing hydrochloric acid and possibly dioxins. All fire residues must be considered contaminated and must be contained for analysis and disposal as appropriate (see Table 13). It is, therefore, important for PCP wood preservation facilities to devise an adequate contingency plan for fire protection.

In addition to the recommendations in section 12.2 of Part I, Chapter A - General Background Information and Recommendations, the following considerations should be contained in the fire contingency plan:

- assure that PCP blocks and bags are stored in fire-protected areas;
- use foam, dry chemical or carbon dioxide for oil fires.

12 References

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CHAPTER G

Alkaline Copper Quaternary (ACQ) Wood Preservation Facilities

Preservative-specific Information and Recommendations

This chapter must be used in conjunction with Part I -
General Background Information and Recommendations.

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1 Production and Use

Alkaline copper quaternary (ACQ) is a waterborne formulation that is prepared on-site at wood preservation facilities. There are currently three formulations in use, Type B, Type C and Type D. The Type B formulation uses ammonia as the carrier, Type C uses an amine (ethanolamine) as carrier and alkylbenzyl dimethyl ammonium chloride (ADBAC) as co-biocide and the Type D formulation uses an amine (ethanolamine) as the carrier and didecyl dimethyl ammonium chloride (DDAC) as co-biocide. The term "alkaline" is used generally to describe either ammonia or ethanolamine formulations. With either carrier, the formulation is completed by addition of copper oxide and quaternary ammonium compound (quat) to water. ACQ is a relatively new technology that was developed in Canada and technically advanced in the U.S. It has been in commercial production in Europe, Japan and the U.S. since the late 1980s. Wood products treated with ACQ preservative are imported to Canada from the U.S., and commercial production is expected to become significant in Canada in 2003 (Table 1).

The preservative is shipped to wood treating facilities as components. Manufactured amine copper (ACQ-C.2) and ammonia copper (ACQ-C) are shipped in tank trucks or by rail at concentrations of 8 to 10%. The quaternary (quat) component is shipped in totes at concentrations of about 50%. ACQ is prepared as a ready-to-use working-strength solution by addition of a known quantity of ammonia copper or amine copper to a measured amount of water in a mix tank. Quat is then added to achieve a copper to quat ratio of 2:1 by weight in the working solution. Agitation is used in the mixing process that yields a clear blue solution.

ACQ is suited for treatment of all commercially used species and can be applied to those species that are refractory and difficult to impregnate. Major products are lumber and timbers, posts, fencing, decking, playground equipment, foundations, utility poles and plywood. ACQ is suitable for aboveground and ground contact, fresh-water immersion and saltwater splash areas but is not appropriate for use in saltwater marine immersion. It is often used where environmental sensitivities exist for the intended use of the treated wood product. Markets for ACQ are similar to those for CCA and ACA (1). See Table 1 for ACQ usage in Canada.

Table 1 ACQ Usage in Canada

Feature	Characteristics
Delivery format	As individual components by rail, tank trucks and totes. • ammonia copper or amine copper • quaternary ammonium compound
Suppliers to Canadian facilities	Chemical Specialties Inc., Charlotte, N.C. Timber Specialties Inc., Campbellville, Ont.
Estimated use quantity (2003)	600 000-m^3 treated wood (21.5 million cubic feet)
Concentration of work solutions	1 to 5% as total actives
Typical preservative retention in treated wood	4.0- to 12.8-kg/m^3 treated wood (0.25 to 0.8 lb/ft^3)
Major products	Lumber and timbers, fencing, decking, posts, plywood and utility poles

Single-cylinder preservation plants sometimes use more than one preservative. This is not recommended with ACQ as an ongoing practice, but can be done if appropriate precautions are taken and strictly followed. ACQ solutions are basic in pH, while others, such as CCA, are acidic. This situation dictates complete flushing of one preservative from the cylinder, piping and all sumps and collection areas before introduction of the other preservative. In addition, one of ACQ's advantages is that it is free of ingredients such as arsenic and chromium. This environmental and operational advantage may be lost if ACQ is mixed with the components of other preservatives.

2 Physical and Chemical Properties

Copper and quat, the two active components of ACQ, are used because of their biocidal and insecticidal properties and their ability to be retained by wood for long-term protection. Ammonia or amine are used as solvent carriers along with water and are deposited in the wood cells. The physical and chemical properties of ACQ and its constituents are outlined in Tables 2 to 5. The quat can either be didecyl dimethyl ammonium chloride (DDAC) or alkylbenzyl dimethyl ammonium chloride (ADBAC, ABAC).

Table 2 Physical and Chemical Properties of ACQ Solution

Transportation and storage information		
Prepared state: Treating solution on-site (not transported)	**Storage temperature:** Ambient	**Containers/materials**: Plastic, poly-lined or stainless steel. Mild steel for solutions
Concentration: (by wt., as oxides) Working solution 1% to 5%	**Hoses**: Use PVC, rubber, polyethylene or stainless steel fittings only.	**Labels and classification**: Check with the Department of Transport.
Classification: Corrosive liquids, N.O.S.	**Venting:** Provide scrubbing to meet air discharge regulatory limits.	
Physical and chemical properties		
Physical state: Liquid (20°C, 1 atm.)	**Floatability**: Mixes with water	**Colour**: Dark blue
Specific gravity@15°C: 1.20	**Freezing point**: -5°C (23°F)	**Odour**: Sharp, characteristic ammonia or amine smell
Vapour pressure: N/E	**Flash point**: Not applicable	
Solubility: Freely soluble (water)	**pH @15°C**: 9.9	
Hazard data		
Fire *Extinguishing data*: Liquid is non-flammable. Water, foam, halon, carbon dioxide, and dry chemical extinguishing materials may be used. *Fire behaviour*: This product is an irritant, potentially corrosive, and it presents a contact hazard to firefighters. May decompose in a fire to produce copper compounds, ammonia and nitrogen oxides. *Ignition temperature*: Not flammable. *Burning rate*: Not applicable.	**Reactivity** *With water*: No reaction, soluble. *With common materials*: Copper, tin, aluminum and zinc alloys are readily corroded. Avoid contact with strong acids. *Stability*: Stable.	

Table 3 Physical and Chemical Properties of Ammoniacal Copper Solution

Identification

Common synonym:
ACQ-C

Manufacturer:
Chemical Specialties, Inc., Charlotte, N.C.

Transportation and storage information

Shipping state: Liquid concentrate
Concentration: 5%-10% copper, 10%-20% ammonium hydroxide
Classification: Corrosive liquid
Storage temperature: Cool, dry location. Avoid excessive heat.

Venting: No requirement
Containers/materials for shipping: Plastic (poly), or stainless steel
Labels: Required. Check with Department of Transport

Physical and chemical properties

Physical state: Liquid
Vapour pressure: Not established
Solubility: Freely soluble (water)
Floatability: Sinks and readily mixes in water
Specific gravity @15°C (59°F): 1.20
Boiling point: Not established

Vapour density: Not established
Flash point: Not flammable
Explosive limits: Not applicable
Colour/appearance: Dark blue, aqueous liquid
Odour: Ammonia smell
pH @ 15°C: 9.9

Hazard data

Fire
Extinguishing data: Liquid is not flammable. Most extinguishing agents can be used on fires involving ammoniacal copper solutions.
Fire behavior: Liquid is not flammable. When involved in a fire, this material may decompose and produce copper compounds, ammonia and nitrogen oxides. Irritant, potentially corrosive and presents a contact hazard to firefighters.
Ignition temperature: Not flammable
Burning rate: Not applicable

Reactivity
With water: No reaction, soluble
With common materials: Avoid contact with copper, tin, aluminum and zinc alloys. Corrosive. Incompatible with strong acids.
Stability: Stable

Table 4 Physical and Chemical Properties of Amine Copper Solution

Identification	
Common synonym: ACQ-C2	**Manufacturer**: Chemical Specialties, Inc., Charlotte, N.C.
Transportation and storage information	
Shipping state: Liquid	**Venting**: Open containers slowly in well ventilated area.
Concentration: 9% copper from mixed ethanol amine complexes	**Containers/materials for shipping**: Plastic, polylined steel drums, stainless steel.
Classification: Corrosive liquid	**Labels**: Required. Check with Department of Transport.
Storage temperature: 10°-30°C (50°-86°F)	
Physical and chemical properties	
Physical state: Liquid	**Vapour pressure**: Not available
Specific gravity (water=1): 1.22	**Flash point**: Not applicable
Solubility: Soluble in water	**Explosive limits**: Not applicable
Floatability: Sinks and mixes readily with water	**pH**: 9–10
Melting point: Not applicable	**Colour**: Blue
Boiling point: Not available	**Odour**: Faint ammonia like odor. Odour threshold 3 ppm (amine compound)
Vapour density (air = 1): >1	
Hazard data	
Fire *Extinguishing data*: Not flammable. Most extinguishing materials are compatible for surrounding area. *Fire behaviour*: Severely irritates contaminated tissue and presents contact hazard for firefighters. May decompose and produce irritating vapours and toxic gases (carbon monoxide, carbon dioxide, copper compounds and nitrogen oxides) *Burning rates*: Not applicable	**Reactivity** *With water*: No reaction *With common materials*: Incompatible with strong oxidizing agents, strong acids and materials that are not compatible with water *Stability*: Stable

Table 5 Physical and Chemical Properties of Quaternary Ammonium Compounds

Identification	
Common synonym: Quat, DDAC, ADBAC	**Manufacturer**: Various
Transportation and storage information	
Shipping state: Liquid	**Venting**: Open containers slowly and in well ventilated areas.
Concentration: 50% by weight	**Containers/materials**: Plastic or polylined steel
Classification: Corrosive material	**Labels**: Pesticide label required
Storage temperature: 10°-30°C (50°-86°F)	
Physical and chemical properties	
Physical state: Liquid	**Vapour pressure**: Not established
Specific gravity (water=1): 0.891	**Flash point**: Not applicable
Solubility: Soluble in water	**Explosive limits**: Not applicable
Floatability: Floats on water, mixes readily	**pH**: 6.6–9.0
Melting point: Not established, liquid	**Colour**: Clear, colourless to pale yellow
Boiling point: Not established, liquid	**Odour**: Faint, alcohol-like
Vapour density (air=1): >1	
Hazard data	
Fire *Extinguishing data*: Not flammable. Most fire extinguishing materials are compatible for surrounding areas. *Fire behavior*: May decompose and produce irritating vapours and toxic gases (carbon monoxide, carbon dioxide and nitrogen oxides) *Ignition temperature*: This product must be substantially preheated before ignition can occur. *Burning rate*: Not applicable	**Reactivity** *With water*: No reaction. Soluble *With common materials*: Reacts with strong oxidizing agents, strong acids and materials that are incompatible with water. *Stability*: Stable

Table 6 Physical and Chemical Properties of Ethanolamine

Identification	
Common synonym: Ethanolamine, MEA, glycinol	**Manufacturer**: Various
Transportation and storage information	
Shipping state: Liquid	
CAS No.: 141-43-5	
Physical and chemical properties	
Physical state: Liquid	**Vapour pressure**: 0.2 mm Hg at 20°C
Specific gravity (water=1): 1.01	**Flash point**: 85°C (closed cup)
Solubility: Soluble in water	**Explosive limits**: Not applicable
Floatability: Mixes readily with water	
Melting point: 10°–12°C	**Colour**: Clear, colourless
Boiling point: 170°C	**Odour**: ammonia-like
Vapour density (air=1): 2.1	
Hazard data	
Fire *Flammability*: Flammable. *Fire behaviour*: May decompose and produce irritating vapours and toxic gases.	**Reactivity** *With water*: No reaction. Soluble, hygroscopic. *With common materials*: Reacts with strong oxidizing agents, strong acids and materials that are incompatible with water.

3 Environmental Effects

3.1 Distribution in the Natural Environment

Ammonia and copper are found naturally in the environment. Amines are derived from ammonia and are not naturally occurring. Quats are synthetically produced and are not naturally occurring; so all Quat found in the environment is assumed to be from human-made sources. Typical background levels of naturally occurring ACQ constituents are listed in Table 7.

Considerable variation occurs in natural concentrations of copper and ammonia in soils and waters (2). Because ammonia concentrations may vary both spatially and temporally, it is important to determine background levels immediately prior to operation of a facility, to enable meaningful future assessments of pollution control.

3.2 Aquatic Toxicity

In considering the aquatic toxicity of ACQ, the following points should be borne in mind:

- Ammonia copper, amine copper and quats are individually delivered and handled at ACQ facilities; therefore the toxicity of each as well as the toxicity of the mixture should be considered.

- The valence of copper may change in the environment, and these changes may reduce or enhance copper's toxicity. No studies have been reported in the literature on valence inter-conversion of copper in soils, groundwater or surface runoff waters at or from wood preserving facilities. Nonetheless, it is known that reduced forms of copper rarely occur in aqueous environments (2).

The guidelines and limitations for copper noted in Table 7 are based on total concentrations, reflecting their recommendations of many scientific reviews that indicate that the current state of knowledge does not enable water quality limitations to be based on either valence state or dissolved fractions in water (3).

The observed chronic toxicity and acute toxicity values of ammonia, copper, didecyl dimethyl ammonium chloride (DDAC) and ACQ treating solution for salmonid species are summarized in Table 8.

In British Columbia, where DDAC is used in anti-sapstain formulations, provincial regulations state that the concentration of DDAC in effluent shall not exceed 700 µg/L (10).

Table 7 Natural Background Levels and Canadian Limitations for Ammonia and Copper

	Typical background levels in environment	
Component	**Surface waters (mg/L)**	**Soils (mg/L)**
Copper (Cu)	<0.001 to 0.04	2-100
Ammonia (NH_3)	<0.01	1-5 ppm (as NH_4^+)

Element	**IJC Recommendations[(a)] Great Lakes waters**	**Canadian drinking water objectives[(b)]**	**Canadian water quality guidelines [(c)]**
Ammonia	0.02 mg/L (non-ionized) for the protection of aquatic life	No guideline in place	Guideline varies from 0.043 to 153 mg/L depending on pH; e.g. 2.2 mg/L at pH 6.5 to 7.5 and 10°C; 0.45 mg/L at pH 8.5 and 10°C[(d)]
Copper	0.005 mg/L for the protection of aquatic life	Maximum acceptable 1.0 mg/L Objective[(c)] :< 1.0 mg/L	For protection of aquatic life: 0.002mg/L hardness 0 to 60mg/L as $CaCO_3$ 0.003mg/L hardness 60 to120mg/L as $CaCO_3$ 0.004mg/L hardness 120 to 180mg/L as $CaCO_3$ 0.006mg/L hardness >180mg/L as $CaCO_3$
DDAC			For protection of aquatic life [(b)] 0.0015 mg/L

(a) Recommendations of the International Joint Commission of the Governments of Canada and the United States, 1987 (3).
(b) CCME 2003, Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment (4).
(c) Guidelines consider local conditions (e.g. background levels) (5).
(d) Guideline is based on total ammonia concentration (non-ionized and ionized forms) (5).

Table 8 Aquatic Toxicity of Ammonia, Copper and Quat (DDAC)

Element	Concentration (mg/L)	Effect
Ammonia	0.03 0.1 to 1.4	• no effect concentration for salmonid growth • 96-h LC_{50}* Rainbow trout (6)
Copper (+2)	0.002 0.006 to 0.015 0.02-0.89 (depending upon water hardness)	• avoidance Atlantic salmon (7) • cough-frequency increase Brook trout (7) • 96-h LC_{50}* • Rainbow trout
Quat (DDAC)	1.24	• 96-h LC_{50}* Rainbow trout (8)
ACQ 3% treating solution	0.0015%	• 48-h EC_{50}* *Daphnia magna* (9)

*LC_{50} is defined as that concentration which results in death of 50% of the fish population within 96 hours. EC_{50} is defined as that concentration, which results in the immobility of 50% of the test population within 48 hours. Because mortality could not be confirmed in all cases in the *Daphnia magna* test, this result is based on immobility of the test organisms and is presented as an EC_{50}.

4 Human Health Concerns

Ammonia and copper are found naturally in food, water and air. The following tables provide estimated daily intakes of these elements by the general population (11).

One safety objective of industrial usage of any chemical (in this case ammoniacal copper, amine copper or quat) is to minimize worker exposure to the chemical, ideally so that natural intake levels are not exceeded. If safeguards are not provided or implemented, then a variety of human health effects may occur depending on the duration and manner of exposure, concentration of chemicals, chemical forms (valence), and varying metabolic sensitivities of individual workers.

The data in Tables 9 to 12 suggest a potential for the constituent chemicals of ACQ to cause adverse effects on human health, particularly at sites where excessive exposure may occur. Various investigators have suggested that the following protective measures be adopted within the wood preserving industry:

- use of clean and undamaged impervious gloves when handling treating solutions and freshly-treated products, to reduce potential for dermal exposure (12);
- adequate worker education and good safety practices at all sites (13);
- proper eye, skin and respiratory protection (13);
- precautions during formulation of treating solutions (12).

Table 9 Potential Health Effects of Exposure to Ammonia Copper Solutions

		Possible health effect	
Exposure category	**Type of exposure**	**Short-term exposure**	**Longer-term exposure**
General population	Estimated daily intake from food, water and air of: Ammonium hydroxide: 572 mg Copper oxide: 3 mg	None reported	None reported
Properly protected worker	Minimal	None reported	None reported
Exposed worker with significant skin or eye contact	Skin or eye contact	Skin: mild irritation Eyes: irritation, pain and reddening (14)	Skin: ulceration, chemical burns, dermatitis Eyes: may cause blindness
Exposure to contaminated aerosols	Inhalation of vapours	Corrosive irritation or burns to nose, throat and lungs, coughing, difficulty breathing (15)	Chemical pneumonitis, pulmonary edema, death
Ingestion	Ingestion of work solution or concentrates	Irritation and burns of the mouth, throat, esophagus, and digestive system (14)	May be fatal

Table 10 Potential Health Effects of Exposure to Amine Copper Solutions

		Possible health effect	
Exposure category	**Type of exposure**	**Short-term exposure**	**Longer-term exposure**
General population	Estimated daily intake from food, water and air of: Copper oxide: 3 mg Amine: Not established	None reported	None reported
Properly protected worker	Minimal	None reported	None reported
Exposed worker with significant skin or eye contact	Skin or eye contact	Skin: irritation, reddening Eyes: irritation, pain and reddening	Skin: ulceration, chemical burns, dermatitis Eyes: May cause blindness
Exposure to contaminated aerosols	Inhalation of vapours	Corrosive irritation or burns to nose, throat and lungs, wheezing, difficulty breathing, visual disturbances	Liver and kidney disorders, adverse lung effects, pulmonary edema, death
Ingestion	Ingestion of work solution or concentrates	Irritation and burns of the mouth, throat, esophagus, and digestive system	May be fatal

Table 11 Potential Health Effects of Exposure to Quaternary Ammonium Compounds

		Possible health effect	
Exposure category	**Type of exposure**	**Short-term exposure**	**Longer-term exposure**
General population	Not applicable	None reported	None reported
Properly protected worker	Minimal	None reported	None reported
Exposed worker with significant skin or eye contact	Skin or eye contact	Skin: redness, itching Eyes: redness, watering, blurred vision	Skin: Dermatitis Eyes: Tissue damage, blindness
Exposure to contaminated aerosols	Inhalation of vapours	Respiratory irritation, dizziness, central nervous system effects	Potentially fatal lung damage, chemical pneumonitis
Ingestion	Ingestion of work solution or concentrates	Gastric distress, nausea, vomiting, diarrhea	Severe ingestion overexposure may be fatal

Table 12 Potential Health Effects of Exposure to ACQ Solutions

		Possible health effect	
Exposure category	**Type of exposure**	**Short-term exposure**	**Longer-term exposure**
General population	Estimated daily intake from food, water and air of: Ammonium hydroxide: 572 mg (11) Copper oxide: 3 mg	None reported	None reported
Properly protected worker	Minimal	None reported	None reported
Exposed worker with significant skin or eye contact	Skin or eye contact	Skin: Irritation, reddening Eyes: irritation, reddening, pain, blurred vision	Skin: ulceration, chemical burns, dermatitis Eyes: May cause blindness
Exposure to contaminated aerosols	Inhalation of vapours	Corrosive irritation or burns to nose, throat and lungs, coughing, difficulty breathing, central nervous system effects	Chemical pneumonitis, pulmonary edema, liver and kidney disorders, death
Ingestion	Ingestion of work solution or concentrates	Irritation and burns of the mouth, throat, esophagus, and digestive system, gastric distress, vomiting	May be fatal

5 Description of Preservative Application and Potential Chemical Discharges

5.1 Description of Process

ACQ preservatives, whether amine or ammonia versions, are water-based products, which are applied by pressure treatment in essentially the same manner as CCA and ACZA (Figure 1). Vacuum and pressure cycles are varied depending on the wood species and size of the wood product being treated, such that they achieve penetration of the preservative into the wood to meet the desired standard (16) or specification. ACQ is prepared on-site at wood preservation facilities from concentrates of either ACQ-C (ammonia version) or ACQ-C2 (amine version) and quat with water to form a working strength solution of 1.0 to 5.0% actives (copper plus quat). The strength of the working solution is determined by the amount of preservative to be retained in the wood. The working solution is applied to wood that has been loaded into pressure cylinders varying in size depending on the wood products being treated. They are generally from 20 to 50 m long, and about 2 m in diameter.

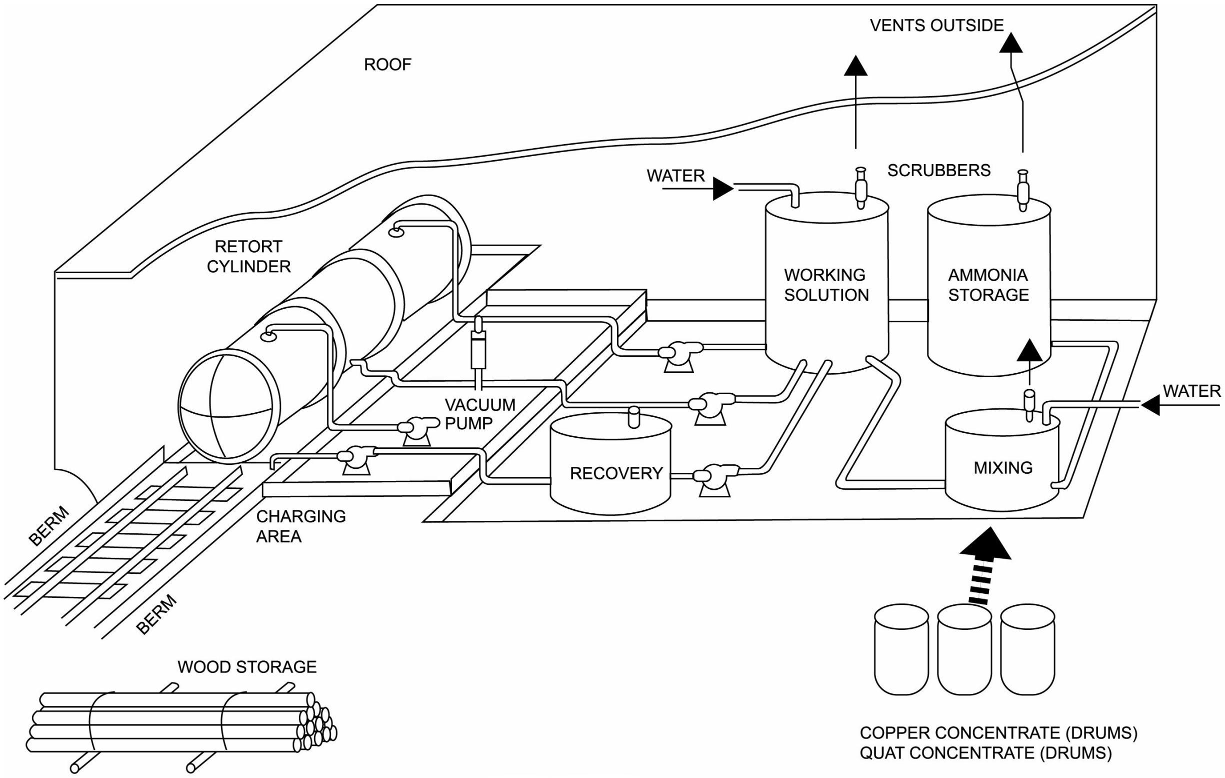
The treatment process used in ACQ treatment plants consists of the basic steps as shown in Figure 2. Application of an initial vacuum to remove air from the wood cells precedes flooding with ACQ working solution and application of pressures of up to 1040k Pa (150 psig) until the target ACQ penetration and retentions are achieved. Pressure is then released and a final vacuum drawn to remove excess preservative solution. The excess solution is returned to the working tank for reuse with subsequent charges. The treated wood is then removed from the treating cylinder and stored on a drip pad until all drippage has ceased, and it can be safely moved to a storage yard. Various methods are being used to enhance the removal of solvent (ammonia or amine) to minimize potential leaching of the preservative actives from the wood.

The specific treatment times and pressures are dictated by the species of the wood, the wood product and the moisture content of the wood. A predetermined range of process parameters is defined by the applicable treatment standards (16), and quality control tests are carried out to ensure that a minimum treated product quality is maintained. The treated wood is stored on-site until ready for shipment.

5.2 Potential Chemical Releases

The potential sources and releases from plants using ACQ are illustrated in Figure 3. Based on the plant design and operational practices, various potential emission sources exist that may affect the environment and/or worker health.

Figure 1 Conceptual Diagram of an ACQ Treatment Facility



Note: The current ACQ formulation uses ethanolamine not ammonia as a solvent.
For that formulation no ammonia tank would be required.

Figure 2 The Full-Cell ACQ Pressure Treating Process

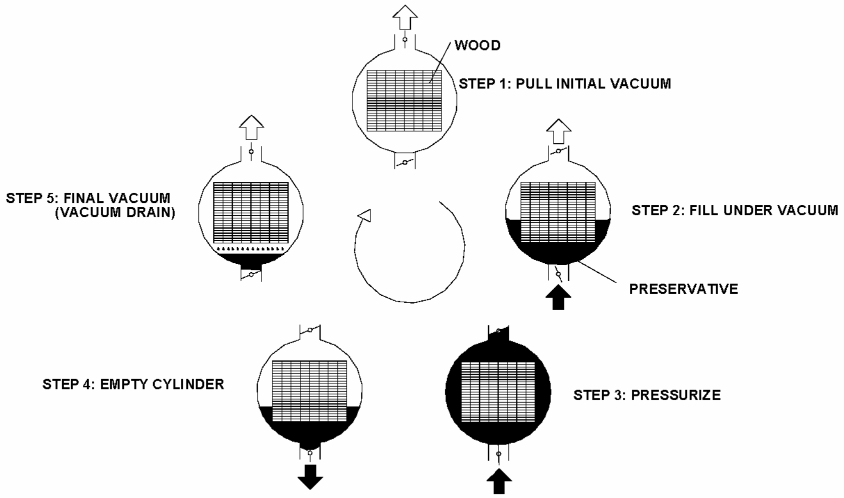
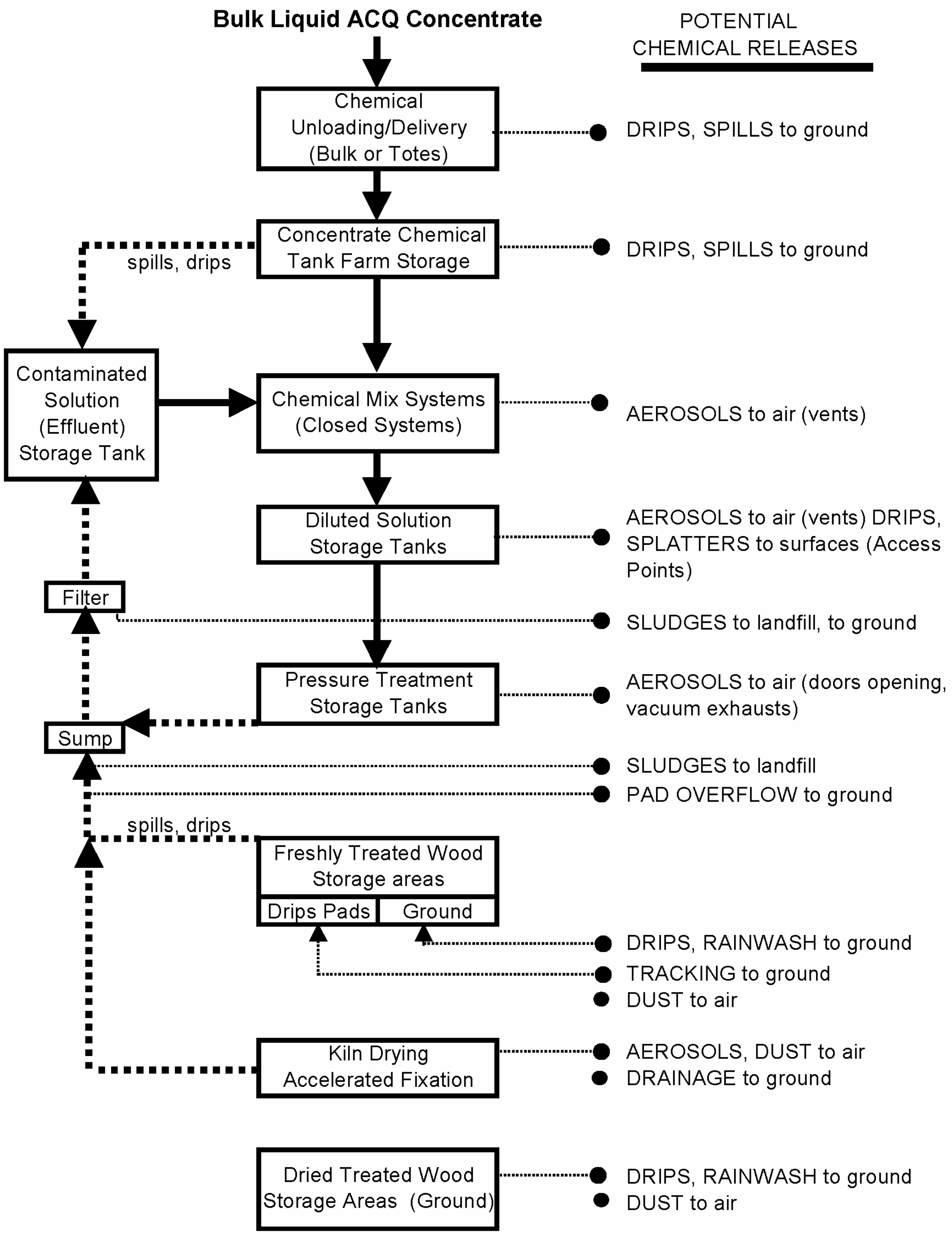


Figure 3 Potential Releases from ACQ Pressure Treating Plants



Liquid Discharges

The ACQ process uses water-borne ingredients and can be operated as a “closed system.” Solution that drips from freshly treated wood or contaminated storm runoff water can be reused in the process. Primary facility design features that should be used for ACQ containment and recycling include:

- concrete containment surfaces and dyking with a second barrier for major process areas including the cylinder and tanks;
- containment surfaces for chemical drips from treated wood on the cylinder discharging track and in the freshly treated wood storage area;
- a collection sump to receive residual preservative from the cylinder (following the treatment cycle), and the accumulated contaminated runoff from other containment surfaces and contaminated stormwater. This material can then be reused in the treatment process following filtration to remove dust and debris.

Under normal operating practices in a properly designed facility there should not be any contaminated liquid discharges. The most common potential sources of contaminated liquid discharges in an ACQ facility are stormwater runoff waters from unpaved and unroofed treated product storage areas. The quantities of preservative in these waters depend on many factors, including quantity of precipitation, fixation method, elapsed fixation time and temperature prior to a precipitation event, and soil characteristics of the storage yard. Uncontained liquid releases other than stormwater are generally confined to yard soils, particularly those locations near drip pads in charging/unloading areas and where containment surfaces are used for freshly treated wood. These contaminated yard soils have potential for causing groundwater contamination.

Solid Wastes

Solid waste generation at ACQ facilities should be small. During normal operating conditions solid waste sources are limited to filters, and to dirt and debris that is periodically scooped from the sump, cylinder and tanks. Treated wood debris and contaminated articles are another source.

Air Emissions

The use of the ammonia formulation implies a significant potential for ammonia emissions at the ACQ facility if proper controls are not in place, and likewise with ethanolamine emissions when the amine formulation is used. Potential sources of release for either of these components include storage and mix tank vents, vacuum pump exhausts, vapours released when cylinder doors are opened, and freshly removed wood charges. Air emission levels should be monitored and appropriate controls such as scrubbers employed where necessary. Air emissions are generally intermittent and restricted to localized areas.

Concentrations of ACQ active components have generally been measured to be below occupational health limits. However, as was the case with ACA facilities, emissions of ammonia have the potential to be higher, dictating the use of a combination of process controls and personal protective equipment, specifically on mixing and in the immediate vicinity of cylinder doors during openings and vacuum exhausts. (12)

5.3 Potential Effects of Chemical Releases

The actual impact of any chemical release depends on many factors including the location of the wood preservation facility relative to ground or surface waters, the amount and concentration of preservative released, the frequency of releases and contingency measures in place at the facility.

There have been no documented environmental or worker health effects as a result of “normal” usage of ACQ preservatives at wood preservation facilities. However, improperly designed and/or operated facilities would have the potential to contaminate site soils and groundwaters, to levels that would prevent the use of such groundwaters for drinking.

Human health effects could occur as a result of improper controls during preparation of ACQ, exposure to minor spills and residues in working areas, and improper handling of, in particular, freshly treated products.

6 Personnel Protection

6.1 First Aid

When exposure to a chemical occurs, the severity and speed of damage to human health depends on the concentration. The general rule is as follows: high concentration demands the highest level of protection. Immediate response is required if a worker is exposed to ammonia copper, amine copper, quats or ACQ work solutions. Tables 13 to 16 outline first aid measures for exposure to ACQ and its constituents.

Table 13 First Aid for Exposure to Ammonia Copper Solutions

Exposure	First action	Second action
Eye contact	• Open victim's eyes while keeping the eyes under gently running water for 15 minutes. Use sufficient force to open eyelids. Have victim "roll" eyes.	• Get medical attention
Skin contact	• Remove contaminated clothing, taking care not to contaminate eyes. Run water over affected areas for 15 minutes.	• Get medical attention
Inhalation	• Remove victim to fresh air. If necessary, use artificial respiration to support vital functions.	• Get medical attention
Ingestion	• If professional advice is not available, do not induce vomiting. Victim should drink milk, egg whites, or large quantities of water.	• Call physician or poison control center for further advice. Get medical attention.

Table 14 First Aid for Exposure to Amine Copper Solutions

Exposure	First action	Second action
Eye contact	• Open victim's eyes while keeping the eyes under gently running water for 15 minutes. Use sufficient force to open eyelids. Have victim "roll" eyes.	• Get medical attention
Skin contact	• Remove contaminated clothing, taking care not to contaminate eyes. Run water over affected areas for 15 minutes.	• Get medical attention
Inhalation	• Remove victim to fresh air. If necessary, use artificial respiration to support vital functions.	• Get medical attention
Ingestion	• If professional advice is not available, do not induce vomiting. Victim should drink milk, egg whites, or large quantities of water.	• Call physician or poison control center for further advice. Get medical attention.

Table 15 First Aid for Exposure to Quaternary Ammonium Compounds

Exposure	First action	Second action
Eye contact	• Open victim's eyes while keeping the eyes under gently running water for 15 minutes. Use sufficient force to open eyelids. Have victim "roll" eyes.	• Get medical attention
Skin contact	• Remove contaminated clothing, taking care not to contaminate eyes. Run water over affected areas for 15 minutes.	• Get medical attention
Inhalation	• Remove victim to fresh air. If necessary, use artificial respiration to support vital functions.	• Get medical attention
Ingestion	• Do not induce vomiting unless directed by medical personnel. Have victim rinse mouth with water if conscious. Victim should drink milk, egg whites, or large quantities of water.	• Call physician or poison control center for further advice. Get medical attention.

Table 16 First Aid for Exposure to ACQ Working Solutions

Exposure	First action	Second action
Eye contact	• Open victim's eyes while keeping the eyes under gently running water for 15 minutes. Use sufficient force to open eyelids. Have victim "roll" eyes.	• Get medical attention
Skin contact	• Remove contaminated clothing, taking care not to contaminate eyes. Run water over affected areas for 15 minutes.	• Get medical attention
Inhalation	• Remove victim to fresh air. If necessary, use artificial respiration to support vital functions.	• Get medical attention
Ingestion	• Do not induce vomiting unless directed by medical personnel. Have victim rinse mouth with water if conscious. Victim should drink milk, egg whites, or large quantities of water.	• Call physician or poison control center for further advice. Get medical attention.

First aid personnel should periodically verify up-to-date response measures with chemical suppliers and/or industrial physicians.

6.2 Regulatory Controls

Most regulatory criteria established by worker protection agencies are based on the threshold limit values (TLVs) and biological exposure indices recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH-recommended limits for ammonia, copper and quat are summarized in Table 17.

Skin and Eye Contact

The ACGIH does not provide a recommended limit for ACQ, as such. For skin and eye contact with individual components of ACQ, the ACGIH provides the following comments (17).

- A TLV of 18 mg/m^3 ammonia has been selected to protect against irritation to eyes and the respiratory tract and to minimize the discomfort among unaccustomed workers. A short-term exposure limit of 24 mg/m^3 is suggested.
- A TLV of 7.5 mg/m^3 ethanolmine has been selected to protect against irritation to eyes and the respiratory tract. A short-term exposure limit of 15 mg/m^3 is suggested.
- A TLV of 1 mg/m^3 (inhalable particulates) for copper has been established, and is based on inhalation.
- Adequate skin, inhalation and eye protection is required during handling of quats. A TLV for quats has not been established.

In cases where ACGIH-recommended limits are based only upon "inhalation" as the route of exposure, these limits may not adequately take into account other routes of exposure. The ACGIH has suggested that in such cases "biological exposure indices may be useful as a guide to safe exposure" (17).

Inhalation

The ACGIH has defined TLVs for many substances based on exposure by inhalation and/or skin exposure. The ACGIH limits for copper, amine and ammonia are based solely on exposure by inhalation. The TLVs are stipulated by the ACGIH as those "airborne concentrations of substances to which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effects." The TLVs for copper, amine and ammonia (17) are defined in Table 17 with the following provisos of the ACGIH:

- "The limits are intended for use in the practice of industrial hygiene as guidelines for good practices or recommendations in the control of potential health hazards and for no other use": (i.e. proof or disproof of the cause of an existing disease or physical condition).
- "The limits are not fine lines between safe and dangerous concentration."
- "In spite of the fact that serious injury is not believed likely as a result of exposure to the Threshold Limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical."
- "When two or more hazardous substances, which act upon the same organ system are present, their combined effect, rather than that of either individually, should be given primary consideration."

Ingestion

Oral intake of ACQ must be avoided. Ingestion of ACQ-containing liquids is unlikely if workers follow the safety precautions outlined in Table 18. Upper limits of ingestion are not prescribed by regulation, because it is generally expected that no such intake will occur. Reported fatal single dose levels for some components of ACQ include:

- 30 mL of 25% ammonia solution (15);
- 1.5 to 3.5 g of copper as copper $^{+1}$ (18).

No values for oral toxicity of amine or quat to humans are defined; however, the following measurements indicate their toxicity to rats:

- ethanolamine LD_{50} oral-rat: 210mg/kg
- DDAC LD_{50} oral-rat: 450mg/kg

Table 17 Levels of Concern for ACQ Exposure in the Workplace

Route of entry	Basis for recommendation	Recommendations/comments
Skin and eye contact	ACQ and ammonia are corrosive	• Protective measures should be used by workers in contact with ACQ solutions. (Table 18). • Avoid direct contact of skin and eyes with all ACQ solutions and ingredients. • Sensitive individuals should take special care to avoid exposure. *Comment*: current material safety data sheets should always be readily available to workers.
Inhalation	ACGIH TLV-time weighted averages (TWA): Ammonia: 18 mg/m^3 air Copper: 1 mg/m^3 air Amine: 8 mg/m^3 air Quat: Not established	• Full face protection and good ventilation should be used during chemical unloading and open mixing operations. • Provide respiratory protection, eye protection and good ventilation: - during unloading and mixing operations and when removing charges of wood, - when welding contaminated equipment, - when ACQ mist or spray is present. • Self-contained breathing apparatus should be used for firefighting activities where ACQ is present. *Comment:* current material safety data sheets should always be readily available to workers.
Ingestion	Literature reports a lethal dose level for 25% ammonia solution of 30 mL; and for copper $^{+1}$ of 1.5 to 3.5 g.	Prevent ingestion of any quantity of ACQ solutions.

6.3 Safety Precautions

Table 18 Safety Precautions for Personnel Working with ACQ Solutions

Objective: To ensure safe workplace practices for each activity during the treatment process.	
Activity	**Recommendations**
Unloading bulk containers	• Wear protective apparel and equipment as specified by the appropriate component material safety data sheet (MSDS). • Prohibit foot or vehicle traffic between the point of delivery and the transport vehicle. • Ensure that at least two individuals trained in handling ACQ are present at all times during unloading operations (i.e. at least one person other than the truck driver; may include forepersons, supervisors and management employees). • Ensure that all connections are secure and leak proof. • Provide an emergency eyewash and shower in the immediate unloading area.
Unloading drums or totes	• Wear protective apparel and equipment as specified by the appropriate component MSDS. • Prohibit foot or vehicle traffic in the area. • Ensure that all connections are secure and leak proof. • Provide adequate equipment for safe, controlled handling of the containers.
Preparing ACQ work solutions	• Wear protective apparel and equipment as specified by the appropriate component MSDS. • Thoroughly clean and hose down the work area to containment area following solution preparation. • Dispose of debris and empty containers according to appropriate component MSDS. • Thoroughly clean protective equipment after use. Reuse all rinse waters for preparing treating solutions. • Provide an emergency eyewash and shower in the immediate area.
Sampling procedures	• Wear protective apparel and equipment as specified by the appropriate component MSDS. • Use sample containers approved for the application and any shipment. • Wash the outside of sample containers immediately after sampling solutions. • Wash hands thoroughly after all sampling operations
Cleaning cylinders or storage tanks	• Follow all standard precautions for vessel entry and confined space (as per provincial health and safety regulations). • Wear protective apparel and respiratory equipment as specified by the appropriate component MSDS. • Flush vessels as required to establish safe entry conditions, or use an approved self-contained breathing apparatus prior to entry. • Always have a standby attendant present, and observe regulations regarding lockout/tagout procedures for confined space entry. • Collect and store contaminated waste material in sealed and labelled drums. • Wash all protective equipment immediately after use. Reuse all rinse waters for preparing treating solutions. • Shower after completion of cleanup tasks.
Removing treated charges from cylinders	• Wear gauntlets during door openings and when moving loads of freshly treated wood • Avoid breathing preservative mists. Wear an approved respirator if airborne concentrations are unknown or at or above TLVs.*
Handling treated lumber	• Wear impermeable** gloves. • Wear impermeable** gloves, apron, boots and eye protection if there is potential for getting splashed by ACQ solution.
Handling and maintaining contaminated equipment	• Thoroughly flush equipment with water prior to handling. Reuse all rinse waters for preparing treating solutions. • Wear impermeable** gloves, apron, boots and eye protection if there is potential for getting splashed by ACQ solution.

Table 18 Safety Precautions for Personnel Working with ACQ Solutions (continued)

Objective: To ensure safe workplace practices for each activity during the treatment process.	
Activity	**Recommendations**
Welding	Welding can produce toxic fumes. In addition to the precautions for handling and maintaining contaminated equipment: • Obtain the specific approval of the plant supervisor before welding. Follow all standard precautions for vessel entry and confined space (as per provincial health and safety regulations). • Block or disconnect lines from tanks before initiating welding operations. • Completely drain and thoroughly rinse tanks or lines prior to welding operations. • Ensure that equipment is completely dry from cleaning solvent residues. • Wear a respirator or provide effective, local exhaust ventilation during welding to prevent potential exposure to toxic fumes. • Provide good general ventilation of the work area. • Comply with all additional provincial workplace safety rules.

* An initial workplace monitoring program will have determined the need for respirator use. The results of the program are assumed to be indicative of conditions in subsequent facility operations, unless procedural or design changes have occurred.

** Heavy-duty, lined polyvinyl chloride, vinyl-coated, neoprene, NBR, or rubber.

7 Design Recommendations

This section suggests approaches for the design and operation of ACQ wood preservation facilities for protection of workers and the environment from harmful effects. Recommendations are based on "best practices" currently in use and must be used in conjunction with the basic design criteria listed in Part I, Chapter A - General Background Information and Recommendations, section 7. The design aspects are intended to achieve the following general objectives:

a) to prevent or reduce direct contact of personnel with ACQ wood preservative chemicals;
b) to reduce releases of ACQ to the environment to the greatest degree possible by providing secure containment of ACQ solutions; and
c) to enable prompt response and effective corrective measures to assure worker safety and environmental protection after abnormal events (e.g., tank rupture)

Means of achieving these design objectives at ACQ wood preservation facilities are presented in Tables 19 to 24. The recommended design features in these tables may not be the sole options available to attain the stated objectives. Alternative approaches may exist which would be equally effective or more suitable to site-specific conditions. If an alternative approach can be demonstrated to be equally effective in attaining the desired objective, an appropriate design feature that has not been included in the recommendations could be used at a specific facility.

Figure 4 presents an overview of subject areas for the design recommendations listed in Tables 19 to 24. The figure is based on the handling and use of ACQ at wood preservation facilities and is cross-referenced to indicate the appropriate table for each subject area.

It is intended that all new wood preservation facilities be designed to achieve the specific objectives listed in Tables 19 to 24. Existing facilities should review their abilities to comply with the objectives and gaps, if present, should be alleviated using the suggested features or alternative but similarly effective features.

Table 19 Recommended Design Features for Chemical Delivery Areas

(Use in conjunction with Part I Chapter A - General Background Information and Recommendations, Table 3.)

Delivery format	Design feature	Recommendations
Bulk liquids: ACQ-C or ACQ-C2 amine and Ammonia-based concentrates (Delivered by truck or rail tanker)	**Objective**: to provide an off-loading area that enhances spill prevention and the containment of spills and to prevent the release of harmful air emissions.	
	Emergency response	• Provide accessible storage for spill response equipment, absorbent and personnel.
Containerized liquids: Ammonia and amine copper concentrates Quat concentrate(totes and drums)	Off loading pad/shelter	• Provide an off-loading area near the storage area.
	Containment	• Assure provision for containment of worst event spill.
	Surfaces	• Provide a sealed surface.
	Container handling	• Design for safe, convenient manipulation of containers.
	Emergency response	• Provide accessible storage for spill response equipment and personnel protection equipment.

Figure 4 Overview of Design Recommendations for ACQ Facilities

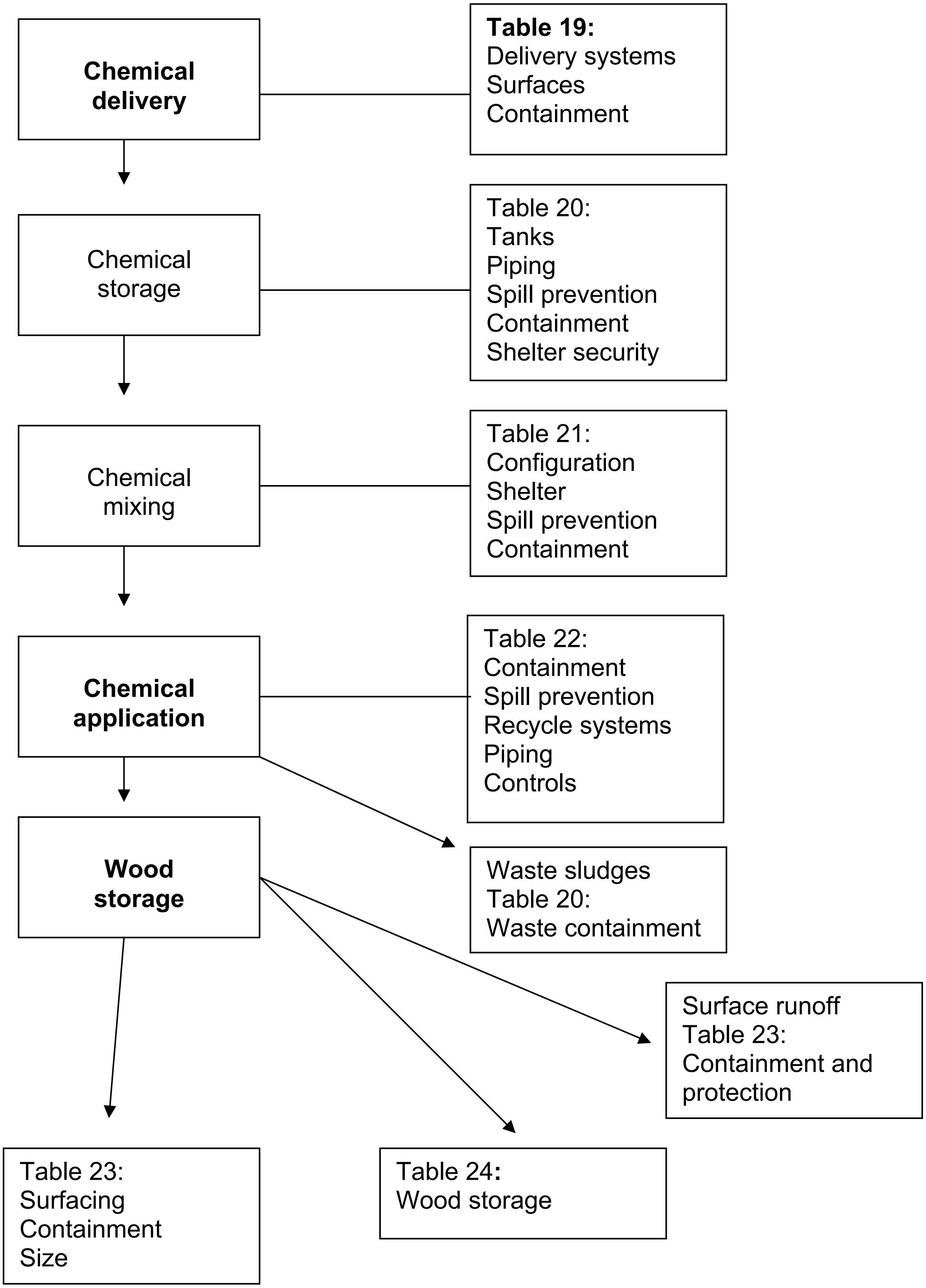


Table 20 Recommended Design Features for Chemical Storage Areas

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 4.

Storage format	Design	Recommendations
• **Bulk ACQ liquids** • working solutions • contaminated surface runoff • drip return	Objectives: To provide positive spill prevention features.	
	To provide spill containment capability for 110% of the volume for a single tank, and in multiple-tank containment provide 100% of the largest tank plus 10% of the aggregate volume of the remaining tanks or 110% of the largest tank whichever is greater, plus 15 cm additional containing wall for single tanks in isolated containment.	
	Tanks	• Engineer tank materials and construction in consultation with chemical suppliers and applicable codes. • Vent tanks to the exterior (never vent to the workplace); - protect vents against release of entrained liquids or overflow (e.g., direct overflow piping to sumps or containment areas).
	Spill containment	• Provide water sprays and/or ventilation to control ammonia vapours
	Backflow prevention	• Install backflow preventers on all waterlines at plant entry. • Use top entry of waterlines to tanks (as secondary backflow protection). • Waterlines must comply with all applicable local codes. • Design to protect against inadvertent transfers to/from interconnected tanks.
	Vapour control	• Install control equipment as required to comply with applicable air emission limits for ammonia and amine vapours. If scrubbers are used, design for recycle and reuse of scrubber fluid.
	Shelter	• Preferred location for ACQ tankage (all solutions) is in a well-ventilated (open sites) tank farm. • If possible, roof exterior tank farms to minimize the quantity of infiltrating precipitation. • Protect from freezing.
	Security	• Provide security precautions to prevent vandalism and access by unauthorized persons.
	Emergency response	• Provide accessible storage for spill-response equipment, absorbents (sawdust for work solutions, drip return, runoff) and personnel protection equipment. • Provide appropriate measures for rapid, effective fire control with containment of liquid firefighting residues and treatment to required limits before discharge. • Provide for emergency ventilation in enclosed spaces. • Install a phone and manual alarm switch near the off-loading area.

Table 20 Recommended Design Features for Chemical Storage Areas (continued)

Storage format	Design	Recommendations
Drummed liquids Amine and ammoniacal copper concentrate and Quat concentrate	Objective: To provide secure storage with containment for the worst-event spill.	
	Location	• Provide safe, easy access to the mixing area.
	Shelter	• Provide storage in an enclosed, secure area, segregated from other chemicals.
	Ventilation	• Provide adequate ventilation for both routine and also emergency requirements.
	Containment	• Store in paved, curbed or dyked area with no floor drains. • Provide containment capacity for the worst-event spill (no fewer than 4 drums). • Provide for effective cleanup (including recovery of washdown water) if a spill were to occur.
	Surfaces	• Seal surfaces and joints to facilitate cleanability and surface impermeability.
	Emergency response	• Provide accessible storage for spill-response equipment, absorbents and equipment for personnel protection as identified in Table 18. • Provide appropriate measures for rapid, effective fire control with containment of liquid firefighting residues and treatment to required limits before discharge.
Drummed wastes: Filter cartridges, sludges, contaminated debris		• Provide a paved area for storing all drummed wastes pending removal to approved disposal • Provide a covered area for drummed wastes.

Table 21 Recommended Design Features for Chemical Mixing Systems

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 5.)

Chemical form	Design feature	Recommendations
• aqua ammonia • working solutions • drip return • contaminated surface runoff	Objectives: • To provide a mixing system with effective spill-prevention features. • To provide a mixing system that minimizes worker contact with ACQ and its components.	
	Configuration	• Use permanent, closed systems (rigidly piped, tank to tank).
	Location/shelter	• Locate mixing and working solution tanks in an enclosed, heated area, particularly if subfreezing temperatures are encountered during operation.
	Spill prevention	• Install high-level alarms to prevent mixing tank overflow. • Interlock high-level alarms to tank feed pumps. • Provide equipment to enable safe, controlled manipulation of ingredients drums. • Provide equipment for transferring drum contents with minimum worker contact and minimum spill potential.
	Spill containment	• Provide all applicable features for “spill containment of bulk liquids”(Chemical storage area, Table 19).
	Splash protection	• Discourage open transfer operations, if unavoidable, provide reliable splash protection

Table 22 Recommended Design Features for Treatment Process Systems

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 6)

Design feature	Recommendations
Objectives: • To minimize and contain all releases of ACQ. • To recover and recycle liquids that are released.	
Spill containment	• Reuse contaminated liquids or treat contaminated liquids to applicable limits before discharge. • Isolate control and transfer equipment to avoid damage from spilled liquids in containment areas.
Ventilation	• Provide adequate routine and emergency ventilation to control preservative component vapour levels in all work areas.
Process emissions to air	• Vent all air emissions (including tank vents and vacuum pump exhausts) to the building exterior. • Install control equipment as required to comply with applicable air emission limits for ammonia and/or amine. • Install traps on otherwise uncontrolled vents (to remove entrained liquids).

Table 23 Recommended Design Features for Freshly Treated Wood Drip Areas

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 8)

Design feature	Recommendations
Objective: • To minimize losses of preservative chemicals from treated wood: – by providing proper conditions for preservative fixation in freshly treated wood; – by controlling the generation and disposal of contaminated runoff waters.	
Fixation/ stabilization areas	• Provide for storage of all freshly treated wood in a specially designated area, with assured recovery of dripped material and precipitation. Holding time must be sufficient to allow adequate fixation of preservative chemicals (as determined by consideration of wood types, treatment processes, operational practices and other relevant factors) to ensure minimal leaching of chemical, when removed to unprotected area .
Containment	• Provide for paved charge unloading and drip areas, sloped to enable collection and storage of all runoff and infiltrating precipitation (for reuse or controlled discharge under terms of existing regulatory standards • Where storage of runoff waters would be difficult, roofing should be provided.

Table 24 Recommended Design Features for Dry Treated Wood Storage Areas

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 9.)

Design feature	Recommendation
Objective: To minimize and control releases of contaminated surface waters from treated wood storage areas.	
Storage areas	• Where practical, store all dry treated wood under roof or wrap. • Segregate treated wood storage areas from other storage areas and segregate contaminated from uncontaminated runoff water to minimize the need for water treatment and/or recycling.

8 Operational Recommendations

The recommendations for good operating practice listed in this section must be used in conjunction with those in Part I, Chapter A - General Background Information and Recommendations, section 8.

In addition to the design objectives described in section 7, an ACQ facility should develop operating procedures to protect both workers and the environment from potentially harmful exposure to ACQ solutions. The operating procedures should:

a) minimize direct contact of personnel with wood-preserving chemicals;
b) minimize releases of wood-preserving chemicals to the environment;
c) facilitate clear and accurate definition of responsibility and action when emergency response is required.

Recommended operating practices are presented in Tables 25 to 28 and include:

- general practices (Table 25);
- procedures for handling and storing wood preservation chemicals (Table 26);
- practices for operating process systems (Table 27);
- practices for maintenance, cleanout, and shutdown of preservation systems (Table 28).

Table 25 Recommended General Operating Practices for ACQ Pressure Treatments

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 10)

Operation	Recommendations
Objective: • To assure that worker responsibilities are well understood and that site-specific procedures are available in hardcopy for reference	
Procedures	• Prepare (and have readily available) explicit written instructions for all aspects of chemical use, facility operation, maintenance and emergency response. • Identify and communicate precautions for all other on-site handlers of treated wood (including quality control personnel, sorters and transporters).

Table 26 Recommended Operating Practices for Chemical Handling and Storage

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 11.)

Operation	Recommendations
Objective: • To assure worker safety during handling of ACQ concentrate and work solutions. • To assure that ACQ solutions are safely stored.	
Preparation of wood Preservation solutions	• Follow the personnel safety precautions for all procedures (Table 18). • Avoid inhalation, ingestion, or skin or eye contact with ACQ work solutions. • Thoroughly rinse empty copper and quat concentrate containers. • Recycle rinse water. • Return containers to suppliers or reuse sound containers for storage of wastes. • Dispose of unusable containers only in landfills specifically approved for such disposal (section 9).
Storage of wood Preservation chemicals	Assign responsibility for storage areas to trained personnel. • Label storage tanks with the identification of contents by chemical name, type of solution and concentration (e.g. aqua ammonia, ACQ work solution). • Post chemical identity placards, fire and spill emergency response procedures, personnel safety precautions and first aid procedures at storage room entrances. • Provide secure storage areas; restrict access to authorized personnel.

Table 27 Recommended Operating Practices for Process System

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 12)

Operation	Recommendations
Objectives: • To define procedural practices that will enhance environmental and worker safety. • To prevent worker contact with treatment solution and with freshly charged loads.	
Tank vents	• Test tank vents to assure the absence of blockage (suggest once/month).
Trams	• Clean soil and debris from trams to prevent contamination of the preservative. • Thoroughly clean trams if alternative preservative treatments are used. • Wear impermeable gauntlets during handling of freshly treated charges.
Retort opening and charge removal	• Pull charges only when the superficial excess preservative has sufficiently drained. • Avoid exposure to ACQ, amine or ammonia mists, aerosols or vapours. • If airborne concentrations are unknown, or, at or above TLVs, wear an approved respirator (full-face mask is recommended).
Load jams	• Assure presence of a standby attendant. • Shower immediately after tank entry. • Follow standard regulatory safety procedures for tank entry.

* NIOSH = National Institute for Occupational Safety and Health.

NOTE ON PRESERVATIVE FIXATION/STABILIZATION:

Currently very little is known about the leachability of ACQ, methods of prevention and plant methods to verify the degree of fixation. Hence plants must take all necessary precautions to minimize charge drippage (e.g. charge tilting, extended vacuums, hot air purging of cylinder) and allow for at least 24 hours of storage at a minimum of 20°C on a drip pad that allows recovery of all drip liquid. It is preferable if this pad is roofed.

Table 28 Recommended Practices for Maintenance, Cleanout and Shutdown of Treatment Systems

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 13)

Operation	Recommendations
Objectives: • To assure that equipment is maintained in a manner that will minimize releases of ACQ solution and minimize worker exposure to ACQ and its by-products. • To prevent accumulation of ACQ solutions and sludges within the treatment system. • To assure worker safety during cleanout operations. • To assure orderly shutdown prior to long-term closure.	
Equipment maintenance	• Follow all personnel safety precautions during maintenance procedures (Table 18). • Drain and/or clean wood preservation chemicals from equipment prior to maintenance. • Flush equipment thoroughly with water and recycle rinse waters to work solutions. • Thoroughly purge all ammonia vapours and provide effective ventilation. • Use extreme caution if contaminated equipment must be welded (toxic fumes can be generated). • Thoroughly clean surfaces to be welded.
Cleanout	• Observe personnel safety precautions during all procedures (Table 18). • Wash down drip pads regularly to prevent accumulation of ACQ. (The washdown frequency should be determined by site-specific factors including the probability of worker exposure, vehicle traffic and wash down by rain). • Reuse washwater for work solution preparation. • Routinely inspect sludge levels in storage and mix tanks; clean out if necessary. Determine sludge levels of concern (requiring removal) in consultation with ACQ suppliers or technical personnel. • Purge cylinders with fresh air sufficient to permit entry. • If airborne concentrations are unknown, at, or above TLVs, the attendant must wear self-contained breathing apparatus in addition to gloves, rubber boots and impermeable coveralls. • If airborne concentrations are below TLVs, wear respirators (do not exceed the ammonia concentration limit of the cartridge), impermeable gloves and boots, and impermeable coveralls. • Provide a constant standby attendant and continuous outside communication. • Follow standard safety procedures for entry of confined spaces. • Prevent skin contact with sludges. • Remove sludges with equipment used only for cleanout purposes. • Collect, drain and store contaminated material in sealed drums pending disposal (Table 29). • The attendant should shower immediately after cleaning retorts or tanks.
Alarms	• Test all alarms and safety devices at regular intervals (or as specified by the manufacturer).
Long-term shutdown	• Thoroughly clean all equipment that has been in contact with waterborne solutions. • Collect all washwaters generated by cleanup operations (Table 29). • Hold solutions in closed tanks for prolonged shutdown. • Drain all open tanks or sumps. • Assure that temperatures in storage areas are above freezing levels or provide adequate freezing protection for all stored liquids. • In case of permanent shutdown, reuse of treatment solutions at another facility is preferred to disposal.

9 Process Emissions and Disposal

9.1 Control, Treatment and Disposal

Potential process emission sources at ACQ wood preservation facilities were described in section 5.2 and Figure 3. The main categories of process wastes and emissions that may be encountered at ACQ facilities, and recommended disposal methods, are presented in Table 29.

9.2 Liquids Containing ACQ

Liquid process wastes (i.e. >1% total oxides) are not normally discharged from ACQ plants. Liquid solutions (such as drips and washwaters) containing ACQ are routinely collected and reused as make-up waters in preparing new treatment solutions. If unusual circumstances (such as prolonged plant shutdown) prevent on-site reuse, transport such solutions to another facility using ACQ. Disposal should be considered only as a last alternative.

If disposal is unavoidable, specific approval must be obtained from the appropriate regulatory agency. If no suitable means of disposal are readily available, the solutions should be sealed in leakproof containers (see Tables 2–6 to assure compatibility with materials used for containers), labelled and stored in a secure area.

Contaminated storm runoff should be minimized. Various approaches can be used including proper wood treatment process operation (i.e. assure solution quality, proper material placement on trams, and appropriate treatment cycles and final vacuum), roofed areas for treated product storage, adequate fixation prior to storage in the open environment and containment of storm runoff waters. In areas of high rainfall, complete containment may not be economically feasible. If the release of ACQ-contaminated runoff does occur, then guidance (and possibly specific approval) may have to be obtained from the appropriate provincial environmental regulatory agency. Control specifications may depend on factors such as the concentration of contaminants, the volume and frequency of the discharges and the sensitivity of the receiving environment. The discharge of ACQ-contaminated runoff into waters inhabited by fish is subject to the provisions of section 33(2) of the federal *Fisheries Act*, because ACQ contains components deleterious to fish.

9.3 Solids with High ACQ Concentrations

For the purpose of this document, solids with "high ACQ concentrations" include sludges from sumps and cylinders, and disposable cartridge filters used to filter recycled waters. Recovery of the components (copper and quat) would be ideal, but this option is not commercially feasible in Canada at this time. The preferred means of disposal for ACQ-contaminated sludges and cartridge filters is solidification and burial in an approved, secure (hydrogeologically isolated) chemical landfill. It is the responsibility of the waste generator to obtain and comply with approvals required by the jurisdiction in which the disposal site/facility is located.

Solids with high concentrations of ACQ should be drained and stored in leakproof containers while awaiting disposal. Large quantities of such solids should be stored in a specially designed area that is curbed and lined with impermeable material. The area should be roofed or covered by a leakproof tarpaulin to protect the wastes from precipitation. Any seepage or leachate generated at the site should be contained.

9.4 Miscellaneous Solid Wastes

Miscellaneous solid wastes (e.g. empty copper concentrate and quat drums, cuttings from ACQ-treated lumber) from ACQ wood preservation plants may be disposed of as approved by the provincial regulatory agency. The ingredient drums should be rinsed with water prior to disposal, and the rinse water should be used for the preparation of work solutions.

9.5 Air Emissions

Air emissions at ACQ facilities are normally localized; effects, if any, would be confined within the boundaries of the facilities. Air emissions from ACQ facilities include vapours from:

- ammonia/copper or amine/copper storage tank vents,
- ACQ mixing and storage tank vents,
- vacuum pump discharge,
- opening of retort cylinder doors, and
- freshly treated charges.

Although information is not yet available for ACQ facilities, there have been studies on the ammoniacal copper arsenate preservative ACA. Monitoring of mists (12) in the vicinity of several ACA retorts during cylinder door openings has shown arsenic and copper concentrations below published ACGIH threshold limit values (17). Ammonia emissions in the vicinity of ACA retort cylinder door openings and in the vicinity of freshly treated wood have been reported at concentrations above occupational health limits. For example, Todd and Timbie (12) measured airborne ammonia concentrations of up to 250 ppm within localized areas of one ACA facility. These concentrations were much above occupational health limits of 35 ppm for a 15-minute exposure and 25 ppm. for an 8-hour exposure. Concern about ammonia releases and control measures at an ACA facility also has been expressed in an Environment Canada report (13).

10 Emission and Site Monitoring

Site monitoring and assessment is required at ACQ facilities, in accordance with the design and operating objectives described in this document, to verify that wood preservative chemicals are being properly managed at the site and to ensure environmental and worker health protection. Also, assessment records will allow an orderly assessment of site decommissioning requirements if a plant is shut down.

Environmental monitoring requirements for most ACQ facilities would normally be developed in consultation with the appropriate provincial environmental regulatory agency. Additional consultation would be required with Environment Canada if the facilities have a potential to impact on federally managed resources (e.g. facilities located on or adjacent to Indian lands, or facilities located adjacent to waters used by anadromous fish such as salmon). Worker health monitoring requirements would be developed in consultation with a provincial workers' compensation board and/or department of labour.

The level of detail and scope of these monitoring activities depends on site characteristics, facility design and the requirements of the regulatory agencies. Components of a site environmental and worker health-monitoring program are suggested in Tables 14 and 15 of Part I, Chapter A - General Background Information and Recommendations.

Table 29 Recommended Disposal Practices for Wastes Contaminated with Ammoniacal Copper Quat

Waste category	Examples	Recommendation
Liquid ACQ solutions	ACQ concentrates and ACQ work solutions Drips from freshly treated lumber Washwaters	• Reuse as make-up for work solutions (standard practice at ACQ plants).
Contaminated solid wastes	Debris and bottom sludge from storage tanks and sumps Debris and sludges from recycle filters (if applicable) that have contacted ACQ	• Drain, drum and dispose of in a secure chemical landfill with prior approval of the regulatory agency.
Miscellaneous solid wastes	Empty concentrate drums	• Rinse thoroughly and dispose of in sanitary landfills designated subject to approval by the regulatory agency.
	Scraps, cuttings and shavings from ACQ-treated lumber and solid fire residues.	• Dispose of in accordance with provincial regulatory requirements
Contaminated storm runoff	Any storm runoff or contaminated liquid discharge that contains quat at levels that exceed provincial concentrations of copper in the receiving environment exceeding 0.005 mg/L, or whose discharge results in ammonia in the receiving environment exceeding 0.020 mg/L.	• Prevent or minimize contamination of storm runoff. • Contain and reuse contaminated runoff • Monitor surface water discharges (in consultation with the provincial regulatory agency) to assess contaminant concentrations.
Firefighting water runoff	As above (contaminated storm runoff)	• Contain and reuse contaminated runoff as makeup for work solutions (to the greatest possible extent). • If reuse is not practical, consult with the provincial regulatory agency to determine acceptable disposal.

11 Transportation of ACQ Components, Solutions and Wastes

The transportation of ACQ components, solutions, and wastes are regulated under the federal *Transportation of Dangerous Goods Act*. The act does not apply to the transportation of treated wood or treated wood wastes. The regulation of intraprovincial movement of dangerous goods is a provincial responsibility.

The stipulated transportation procedures are abstracted in Part I, Chapter A - General Background Information and Recommendations, section 11.

12 Spill and Fire Contingency Planning

Preparedness for emergencies is essential in any wood preservation plant. Hence, facilities using ACQ should prepare and have readily available detailed contingency plans to ensure that response to spills and fires is quick, safe and effective. It is recommended that the individual facility plans be filed with the authorities having jurisdiction.

12.1 Spill Contingency Planning

In addition to the recommendations in the corresponding section 12.1 of Part I, Chapter A - General Background Information and Recommendations, the following recommendations apply to ACQ facilities if a spill of solvent, liquid ingredient or ACQ solution occurs:

- Immediately put on an appropriate full-face mask.
- Always stay upwind to avoid potential exposure to fumes.
- For ammonia spills use water spray to knock down vapours.
- If tanks other than normal work tanks are used for salvage purposes, assure compatibility of materials (e.g. do not use galvanized or aluminum tanks).

12.2 Fire Contingency Planning

In addition to the recommendations in the corresponding section 12.2 of Part I, Chapter A - General Background Information and Recommendations, the following recommendations apply to ACQ facilities in case of a fire.

Although the components and solutions of ACQ are not flammable, precautions should be taken in the event that a fire occurs. Gases could be released from the preservative materials if heated, and mixtures of ammonia and air in enclosed spaces with an ignition source could be explosive.

Using water blankets and water spray to suppress toxic gases and to keep oxidizable materials at temperatures below that for ignition are additional items for the fire contingency plan as recommended in section 12.2 of Part I, Chapter A - General Background Information and Recommendations.

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CHAPTER H

Copper Azole (CA-B)
Wood Preservation Facilities

Preservative-specific Information and Recommendations

This chapter must be used in conjunction with Part I -
General Background Information and Recommendations.

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1 Production and Use

Copper azole (CA-B) is a waterborne formulation that is delivered in concentrate form to wood preservation facilities. Copper azole was originally formulated in the mid-eighties in Europe to meet the demand of consumers requesting an alternative wood preservative. Variants of this formulation have been in commercial production in more than 20 countries worldwide.

The preservative is shipped to wood treating facilities as a concentrate by tanker truck. Agitation is required for the concentrate tank to maintain a homogenous solution. The concentrate is diluted with water to obtain a working solution.

CA-B is suited for treatment of refractory wood species, as well as all commercially used species. It is for use as a heavy-duty wood preservative in the treatment of wood products such as decks, patios, fencing, play structures, boardwalks, picnic tables, landscaping timbers, residential fencing and walkways. It is not currently recognized for use in salt water marine immersion applications.

CA-B and other preservatives, e.g. CCA, are incompatible and will cause chemical problems if used in a single treatment system. (It is therefore not recommend that CA-B be used in the same cylinder as other preservative systems, such as CCA, as an ongoing practice. CA-B solutions are basic in pH; whereas CCA, for example, is acidic. In any case where a switch is unavoidable, the situation would dictate complete flushing of one preservative from the cylinder, piping and pumps and all sumps and collection areas before introduction of the other preservative.

Table 1 CA-B Usage in Canada

Feature	Characteristics
Pest Control Products Act registration number	• 27132
Proportions of active ingredients	• Copper 9.25% Tebuconazole 0.37%
Delivery format	As a concentrate by tanker trucks or totes
Suppliers to Canadian facilities	Arch Wood Protection Canada Corp., Mississauga, Ontario
Estimated use quantity (2002)	Introduced in 2002, no figures yet available
Concentration of work solutions	0.4 to 5% as total actives
Typical preservative retention in treated wood	1.6 to 4.96 kg/m^3 treated wood (0.1 to 0.31 lb/ft^3)
Major products	Decks, patios, fencing, play structures, boardwalks, picnic tables, landscaping timbers, residential fencing and walkways

2 Physical and Chemical Properties

Copper and tebuconazole, the two active components of CA-B, are used because of their fungicidal and termiticidal properties and their ability to offer long-term protection in the wood. Ethanolamine is used as a solubilizing agent for the copper and is deposited in the wood cells. The physical and chemical properties of CA-B are outlined in Table 2.

Table 2 Physical and Chemical Properties of CA-B Solution

Identification		
Common synonyms: Copper azole Wolman® E (CA-B) Wolman® NB	Manufacturer: Arch Wood Protection Inc. (12 locations in the U.S.)	
Transportation and storage information		
Shipping state: Liquid concentrate **Concentration**: 9.62% by weight **Classification**: Corrosive liquids, n.o.s.	**Storage temperature**: Ambient **Inert atmosphere**: No requirement **Venting**: To plant exterior with overflow protection	**Containers/materials**: Carbon or stainless steel. No copper-based alloys **Labels and classification**: Check with Transport Canada
Physical and chemical properties		
Physical state: Liquid (20°C, 1 atm.) **Solubility**: Freely soluble in water pH @15°C: 9.5 to 11.0 **Vapour pressure**: N/E	**Floatability**: Soluble in water **Freezing point**: <-30°C **Flash point**: >93°C **Specific gravity**: 1.18 to 1.22 @ 22°C	**Colour**: Dark blue **Odour**: Negligible
Hazard data		
Extinguishing agents: Use water, dry chemical or other common extinguishing media. *Fire-fighting procedures*: Fire from a separate fuel source may be intense enough to cause thermal decomposition releasing toxic fumes and/or gases. Wear complete fire service protective equipment, including full-face NIOSH- and NFPA-approved* self-contained breathing apparatus. *Fire and explosion hazard*: Moderate fire and explosion hazard when exposed to heat or flame. *Combustible liquid*: May burn. Does not ignite unless there is an ignition source. Flammable, poisonous gases may accumulate in enclosed areas. Avoid contact with or storage with any of the incompatible substances listed in “Stability and reactivity” section of this table.	*Conditions contributing to instability*: Stable under normal conditions *Incompatibilities*: Oxidizers, strong acids, cellulose nitrates, sodium hypobromite, acetylene, hydrazine, nitromethane, aluminum and zinc *Hazardous reactions/decomposition/ combustion products*: Toxic or hazardous oxides of carbon and/or nitrogen *Hazardous polymerization*: Not known to occur	

**Do not weld on empty uncleaned containers.*

NIOSH = National Institute for Occupational Safety and Health. NFPA = National Fire Protection Association.

3 Environmental Effects

3.1 Distribution in the Natural Environment

Copper is found naturally in the environment. Typical background levels of naturally occurring copper are listed in Table 3. As with all metals, there is a wide range of naturally occurring concentrations of copper found in soil, and it is recommended that baseline levels be determined prior to operation of a facility using copper azole, to enable meaningful future environmental assessments.

Ethanolamine and tebuconazole are synthetically produced and are not naturally occurring; therefore all ethanolamine (MEA) and tebuconazole that may be found in the environment is expected to be from human-made sources.

Tebuconazole

Persistence: Tebuconazole degrades approximately 20% in water in Organization for Economic Cooperation and Development (OECD)Test Guideline 301C. Its half-life in soil is around 100 days.

Overall Ecotoxicity Statement, Tebuconazole: Tebuconazole is moderately toxic to aquatic organisms and has a slight potential to bioconcentrate, but it is rapidly eliminated from fish. While tebuconazole is slightly persistent in the environment it has been shown not to be mobile. In addition, light dramatically enhances the degradation process.

MEA in the Environment

Using certain known physical parameters of MEA, such as water solubility and vapour pressure, a computer simulation of the partition of MEA in the environment predicts that MEA should partition primarily into the aqueous component. It is expected to be mobile in soil and is not expected to absorb to suspended solids or sediment in water. MEA readily undergoes biodegradation and is not expected to persist in the environment. Twenty-day BOD values ranged from 40 to 67% biodegradation; a Modified Sturm Test showed 97% biodegradation in 28 days; and a Modified OECD Screening Test showed 94 to 99% biodegradation in 28 days.

3.2 Aquatic Toxicity

The guidelines and limitations for copper noted in Table 4 are based on total concentrations, reflecting the recommendations of many scientific reviews that indicate that the current state of knowledge does not enable water quality limitations to be based on either valence state or dissolved fractions in water (1).

Table 3 Background Levels and Canadian Limitations for Copper

	Typical background levels in environment	
Component	**Surface waters (mg/L)**	**Soils (mg/L)**
Copper (Cu) CAS # 7440-50-8	<0.001 to 0.04	2 to 100

Element guidelines	IJC Recommendations(a) Great Lakes waters	Canadian drinking water objectives(b)	Canadian water quality(c)
Copper	0.005 mg/L for the protection of aquatic life	Aesthetic objective(c) : ≤ 1.0 mg/L	For protection of aquatic life: 0.002mg/L hardness 0 to 60mg/L as $CaCO_3$ 0.003mg/L hardness 60 to 120mg/L as $CaCO_3$ 0.004mg/L hardness 120 to 180mg/L as $CaCO_3$ 0.006mg/L hardness >180mg/L as $CaCO_3$

a) Recommendations of the International Joint Commission to the governments of Canada and the United States, 1977.
b) The term “aesthetic objective” is defined in Federal-Provincial Subcommittee on Drinking Water , 1996 (2).
c) The aesthetic objective is taken from Health Canada’s website, Healthy Environments and Consumer Safety [http://www.hc-sc.gc.ca/hecs-sesc/]. Summary of guidelines for Canadian drinking water quality, Table 2 Summary of guidelines for chemical and physical parameters http://www.hc-sc.gc.ca/hecs-sesc/water/publications/drinking_water_quality_guidelines/ch4.htm (accessed on March 23, 2004).
d) Guidelines consider local conditions (e.g. background levels) (3).

The observed chronic toxicity and acute toxicity values of copper for salmonid species are summarized in Table 4.

Table 4 Aquatic Toxicity of Copper

Element	Concentration (mg/L)	Effect
Copper (+2)	0.002	Avoidance Atlantic salmon (4)
	0.006 to 0.015	Cough-frequency increase brook trout (4)
	0.02 to 0.89 (depending upon water hardness)	96-h LC$_{50}$* rainbow trout

* LC$_{50}$ is defined as that concentration that results in death of 50% of the fish population within 96 hours.

3.3 Aquatic Toxicity Testing for Tebuconazole

Acute effects: Fish: LC$_{50}$ of 4.4 mg/L (96 hr) to trout; of 5.7 mg/L (96 hr) to *Lepomis macrochirus Daphnia*: EC$_{50}$ of 4.2mg/L (48 hr) to *Daphnia magna*.

Acute toxicity to fish: LC$_{50}$ to *Leuciscus idus* is approximately 3.5 mg/L (96 hr); LC$_{50}$ to *Leuciscus idus* is approximately 8.7 mg/L (96 hr); and LC$_{50}$ to *Salmo gairdneri* is approximately 4.4 mg/L (96 hr).

Acute toxicity to *Daphnia* sp.: EC$_{50}$ to *Daphnia magna* is approximately 25 mg/L (24 hr); EC$_{50}$ to *Daphnia magna* is approximately 11.8 mg/L (24 hr).

3.4 Aquatic Toxicity Testing for Ethanolamines

MEA is not expected to bioaccumulate in aquatic organisms with a log octanol:water partition coefficient (log K) of -1.23. MEA has demonstrated a relatively low degree of toxicity to aquatic organisms: the acute fish toxicity (LC) ranges from over 150 to over 300 mg/L (practically nontoxic); the acute *Daphnia magna* toxicity (EC) is greater than 100 mg/L (practically nontoxic); and the acute algae toxicity (LC) ranges from 1 to 10 mg/L (moderately toxic).

4 Human Health Concerns

Any chemical can be handled and used safely if proper precautions are taken by the workers involved. Abuse or noncompliance by workers or employees may result in excessive exposure.

Suggested measures for the wood preserving industry are as follows:

- use of clean and undamaged impervious (nitrile) gloves when handling treating solutions and freshly treated products, to reduce potential for dermal exposure (5);
- adequate worker education and good safety practices at all sites (6);
- proper eye, skin and respiratory protection (6).

Copper is found naturally in food, water and air. Estimated daily intake of copper oxide in the general population is 3 mg with no adverse health effects.

Table 5 Potential Health Effects of Exposure to Copper Amine Solutions

		Possible health effects	
Exposure category	**Type of exposure**	**Short-term exposure**	**Long-term exposure**
Properly protected worker	Minimal	None reported	None reported
Exposed worker with significant skin or eye contact	Skin or eye contact	*Skin*: Irritation, reddening *Eyes*: Irritation, pain and reddening	*Skin*: Ulceration, chemical burns, dermatitis *Eyes*: May cause blindness
Exposure to contaminated aerosols	Inhalation of vapours	Corrosive irritation or burns to nose, throat and lungs; wheezing; difficulty breathing; visual disturbances	Liver and kidney disorders, adverse lung effects, pulmonary edema, death
Ingestion	Ingestion of work solution or concentrates	Irritation and burns of the mouth, throat, esophagus and digestive system	May be fatal

Table 6 Potential Health Effects of Exposure to Tebuconazole Concentrate*

Exposure category	Type of exposure	Possible health effects	
		Short-term exposure	Long-term exposure
Properly protected worker	Minimal	None reported	Minimal
Exposed worker with significant skin or eye contact	Skin or eye contact	*Skin*: Non-irritating, *Eyes*: Non-irritating	*Skin*: None known *Eyes*: Toxic effects may result on the lens of the eye.
Exposure to contaminated aerosols	Inhalation of vapours	No known effects	No known effects
Ingestion	Ingestion of concentrate	Concentrate may be considered slightly toxic orally	Possible toxic effects on the spleen, liver and adrenals

* In the Wolman® NB concentrate, tebuconazole concentration is at 0.37%. Manufacturers data supplied is based upon a pure tebuconazole product. Workers will generally only come into contact with the working solution, which again is 0.37% of the diluted percentage of the working solution.

Table 7 Potential Health Effects of Exposure to Ethanolamine Concentrate

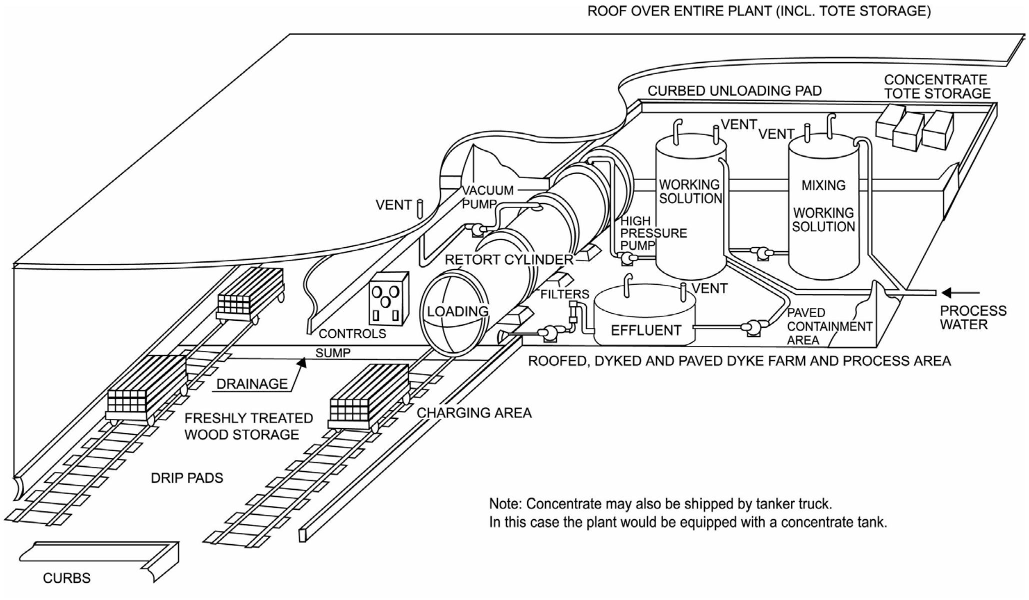
Exposure category	Type of exposure	Possible health effects	
		Short-term exposure	Long-term exposure
Properly protected worker	Minimal	None reported	Minimal
Exposed worker with significant skin or eye contact	Skin or eye contact	*Skin*: Irritating, *Eyes*: Irritating	*Skin*: May cause extreme dermal irritation *Eyes*: May cause severe injury to the eye.
Exposure to contaminated aerosols	Inhalation of vapours	Can be irritating	No known effects
Ingestion	Ingestion of concentrate	Concentrate may be considered slightly toxic orally	Possible toxic effects on kidneys and liver

5 Application and Potential Chemical Discharges at Copper Azole (CA-B) Wood Preservation Facilities

5.1 Application

CA-B working solution is prepared at wood preservation facilities by diluting the preservative concentrate with water to form a working strength solution of 1.0 to 5.0% actives. The working solution strength is determined by the desired treatment level to be retained in the wood. CA-B treating solution is applied by pressure treatment in a similar manner to CCA and ACZA (Figure 1). Vacuum and pressure cycles are varied depending on the wood species and size of the wood product being treated, such that they meet the desired standard (7) or specification.

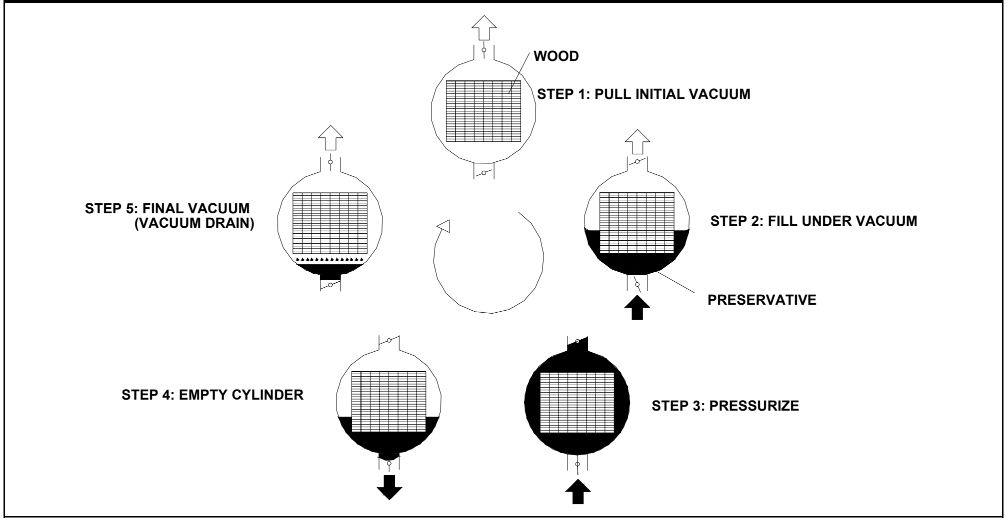
Figure 1 Conceptual Drawing of a Copper Azole Treating Plant



The treatment process used in CA-B treatment plants consists of the following basic steps. An initial vacuum removes air from the wood cells, and then the cylinder is filled with CA-B working solution. Once the predetermined pressure is attained, it is maintained until the desired treatment is achieved. Pressure is then released, the solution is transferred back to the work tank and a final vacuum is pulled to remove excess preservative solution. The wood is removed from the cylinder to a contained drip pad until dripping has ceased. The wood may then be either placed in the storage yard once fixation is complete or moved to an accelerated fixation chamber.

The specific treatment times and pressures are dictated by the species of the wood, the wood product, and the moisture content of the wood. A predetermined range of process parameters is defined by the applicable treatment standards (7), and quality control tests are carried out to ensure that a minimum treated product quality is maintained. The treated wood is stored on site until ready for shipment.

Figure 2 The Full-Cell CA-B Pressure Treating Process



5.2 Potential Chemical Discharges

CA-B wood preservation facilities vary in design and operating practices, which may cause differences in the nature of potential releases from any particular plant.

Liquid Discharges

Solution that drips from freshly treated wood onto drip pads will be reused in the closed system process. The following primary facility design features should be used for CA-B containment and reuse in the treatment process.

- All concrete containment surfaces must have a secondary containment, either by liners or coatings, and be adequately dyked. This applies to the chemical storage area, the cylinder area, the drip pad and any wet wood storage areas.
- A lined collection sump to receive residual preservative from the cylinder following the treatment cycle and the accumulated contaminated runoff from other containment surfaces. This material can then be used as make-up water for new mixes following filtration to remove dust and debris.

Under normal operating practices in a properly designed facility there should not be any contaminated liquid discharges. In the event an accident or spill does occur, the facility should be equipped to immediately clean up the contamination to prevent adverse effects to the environment, and at that time the facility may have to notify the authorities, depending on local regulations.

Once dripping has ceased, freshly treated lumber should be stored in the yard or under sheds. If incidental drippage occurs, the lumber must be returned immediately to the drip pad area until all dripping has been confirmed to have stopped. Immediate cleanup of the drippage should be initiated to prevent any potential for causing stormwater contamination or tracking.

Solid Wastes

Solid waste generation at CA-B facilities should be relatively small. During normal operating conditions solid waste sources are limited to filters, and to dirt and debris that is periodically scooped from the sump, cylinder and tanks. Treated wood debris and contaminated articles are another source.

Air Emissions

The use of an amine formulation at ambient temperature will have minimal tank emissions from normal operation. Typically no controls are necessary for ambient temperature solutions with the CA-B product. There should be no in-plant emissions from storage tank vents or vacuum pump exhausts, as these must be vented to the plant exterior with liquid-release protection.

The use of heated solutions may imply some potential for amine emissions at the CA-B facility if proper controls are not in place.

Potential fugitive emissions for amines based upon personnel and area monitoring at other facilities have been well below American Conference of Governmental and Industrial Hygienists (ACGIH) standards. (These include vapours released when cylinder doors are opened and from freshly removed wood charges). Personnel should still be monitored and appropriate (PPE) personal protective equipment employed where found necessary.

Potential Chemical Releases/Exposures from Wolman® NB Pressure Treatment Plants

- hose ruptures during the unloading of trucks
- overfilling of storage tank or tank failure
- piping failure
- damage of waste drum
- drippage from lumber that was removed from the drip pad too soon

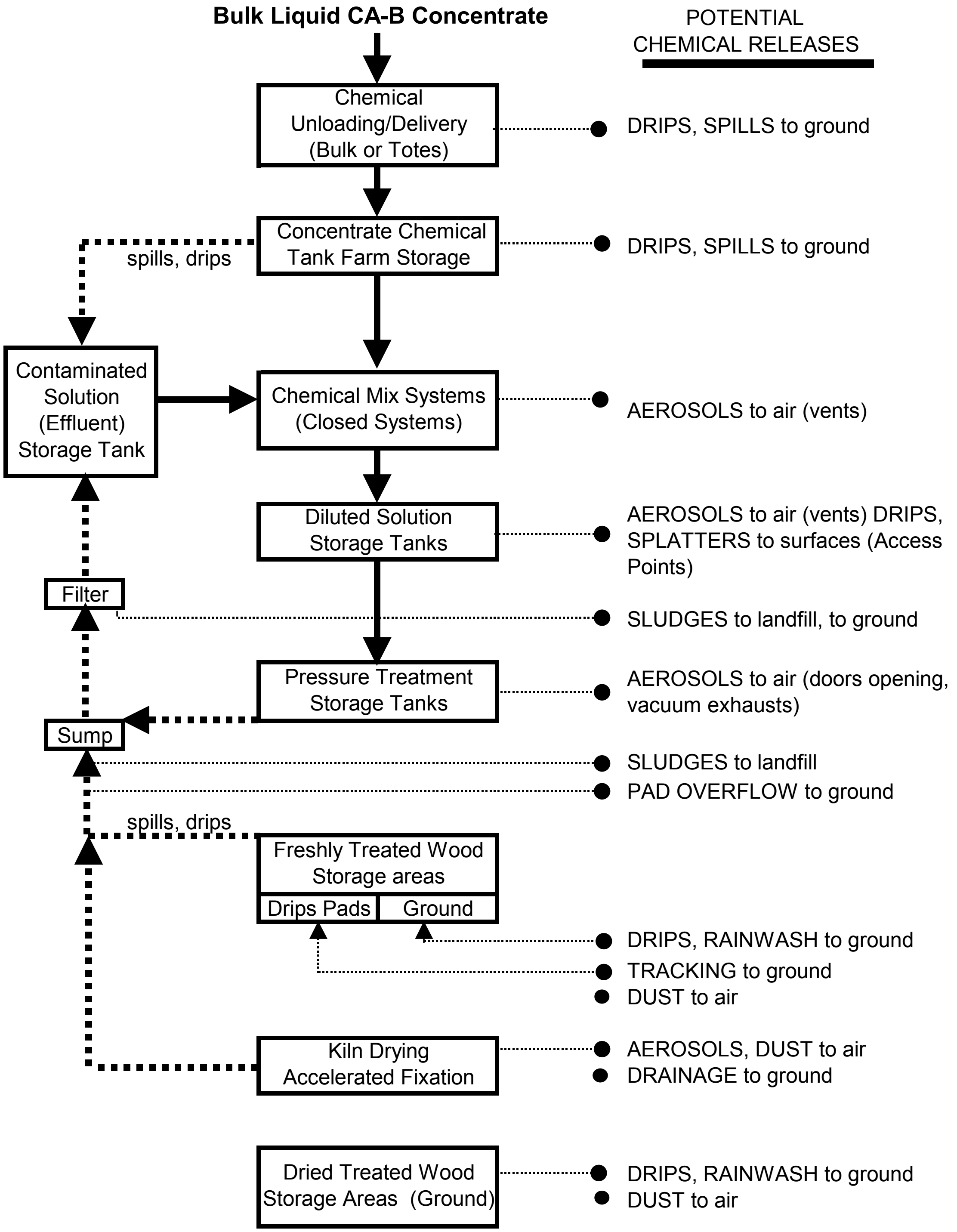
5.3 Potential Effects of Chemical Discharges

The actual impact of any chemical release depends on many factors including the location of the wood preservation facility relative to ground or surface waters, the amount and concentration of preservative released, the frequency of releases, and contingency measures in place at the facility.

There have been no documented environmental or worker health effects as a result of “normal” usage of CA-B preservatives at wood preservation facilities. However, improperly operated facilities have the potential to contaminate surrounding site soils and groundwaters to levels that exceed drinking water standards.

Human health effects for workers are minimized by the use of closed systems for concentrates and working solutions. The main source of potential contact with CA-B would be from improper handling of product.

Figure 3 Potential Releases from CA-B Pressure Treating Plants



6 Personnel Protection

6.1 First Aid

When exposure to a chemical occurs, the severity and speed of damage to human health depends on the concentration. Immediate response is required if a worker is exposed to CA-B concentrate solutions. Tables 8 to 11 outline first aid measures for exposure to CA-B and its constituents.

Table 8 First Aid for Exposure to CA-B Concentrate Solutions

Exposure	First action	Second action
Eye contact	• Immediately flush with large amounts of water for at least 15 minutes. DO NOT rub the eyes. If victim is wearing contact lenses, immediately flush eyes with water for a short period prior to removing contacts, then continue flushing eyes for at least 15 minutes.	• Immediately seek medical aid.
Skin contact	• Flush exposed skin with large amounts of water. Then use soap and water to clean area. Remove contaminated clothing. Immediately seek medical aid if severe irritation develops.	• Immediately seek medical aid.
Inhalation	• Remove from exposure. If severe breathing difficulty should arise, immediately seek medical aid. If breathing has stopped, administer artificial respiration or oxygen.	• Immediately seek medical aid.
Ingestion	• DO NOT induce vomiting. Seek medical aid immediately. Do not attempt to give anything to an unconscious person. Call a physician or poison centre.	• Call physician or poison control center for further advice. Get medical attention.

Table 9 First Aid for Exposure to CA-B Working Solutions

Exposure	First action	Second action
Eye contact	• Immediately flush with large amounts of water for at least 15 minutes. DO NOT rub the eyes. Immediately seek medical aid. If wearing contact lenses, immediately flush eyes with water for a short period prior to removing contacts, then continue flushing eyes for at least 15 minutes.	• Immediately seek medical aid.
Skin contact	• Flush exposed skin with large amounts of water. Then use soap and water to clean area. Remove contaminated clothing. Immediately seek medical aid if severe irritation develops.	• Immediately seek medical aid.
Inhalation	• Remove from exposure. If severe breathing difficulty should arise immediately seek medical aid. If breathing has stopped, administer artificial respiration or oxygen.	• Immediately seek medical aid.
Ingestion	• DO NOT induce vomiting. Seek medical aid immediately. Do not attempt to give anything to an unconscious person. Call a physician or poison center.	• Call physician or poison control center for further advice. Immediately seek medical aid.

First aid personnel should periodically verify up-to-date response measures by reviewing current material safety data sheets (MSDS) with chemical suppliers and/or industrial physicians.

6.2 Regulatory Controls

Most regulatory criteria established by worker protection agencies are based on the threshold limit values (TLVs) and biological exposure indices recommended by the American Conference of Governmental Industrial Hygienists (ACGIH).

Table 10 provides potential exposures and general recommendations for worker protection.

Table 10 Levels of Concern for CA-B Exposure in the Workplace

Route of entry	Basis for recommendation	Recommendations/comments
Skin and eye contact	CA-B concentrate – corrosive CA-B working solution – may be corrosive	• Protective measures should be used by workers in contact with CA-B solutions (Table 11). • Avoid direct contact of skin and eyes with all CA-B solutions and ingredients (10) • Sensitive individuals should take special care to avoid exposure. *Comment*: current material safety data sheets (MSDS) should always be readily available to workers.
Inhalation	ACGIH TLV time-weighted averages (TWA): Copper: 1 mg/m^3 air Amine: 8 mg/m^3 air	• Full face protection and good ventilation should be used during chemical unloading and open mixing operations. • Provide respiratory protection, eye protection and good ventilation: - during unloading and mixing operations and when removing charges of wood; - when welding contaminated equipment; - when CA-B mist or spray is present. • Self-contained breathing apparatus should be used for firefighting activities where CA-B is present. *Comments*: current MSDS should always be readily available to workers.
Ingestion	Literature reports a lethal dose level for copper $^{+1}$ of 1.5 to 3.5 g	Prevent ingestion of any quantity of CA-B solutions
Tebuconazole ingestion	Oral (LD$_{50}$ acute oral rats active technical degree) LD$_{50}$ oral, rate approx: 4000 mg/kg, air, 4 h of exposure. Inhalation (LC$_{50}$ inhalation rats active technical degree) LD$_{50}$ inhalation (dust) rat: more than 5000 mg/m^3. A concentration of dust of 5093 mg/m^3 caused no symptoms and no mortality.	If product is swallowed, rinse the mouth and drink water. If you feel unwell, seek medical advice. Individuals who have inhaled dusts should be taken out into the fresh air. If there is difficulty in breathing, medical attention should be obtained. Respiratory protection: in case of dust formation particle filter, P Type (1)

6.3 Safety Precautions

Following is Table 11, which gives safety recommendations for specific plant activities. Note that the pesticide label may prescribe additional or more stringent requirements for personnel protective equipment for various activities than is indicated here. These label requirements must be followed.

Table 11 Safety Precautions for Personnel Working with CA-B Solutions

Objective: To ensure safe workplace practices for each activity during the treatment process.

Activity	Recommendations
Unloading bulk containers	• Wear protective apparel and equipment as specified by the appropriate component material safety data sheet (MSDS). • Prohibit foot or vehicle traffic between the point of delivery and the transport vehicle. • Ensure that at least two individuals trained in handling CA-B are present at all times during unloading operations (i.e. at least one person other than the truck driver; may include forepersons, supervisors and management employees). • Ensure that all connections are secure and leakproof. • Provide an emergency eyewash and shower in the immediate unloading area.
Unloading drums or totes	• Wear protective apparel and equipment as specified by the appropriate component MSDS. • Prohibit foot or vehicle traffic in the area. • Ensure that all connections are secure and leakproof. • Provide adequate equipment for safe, controlled handling of the containers.
Preparing CA-B work solutions	• Wear protective apparel and equipment as specified by the appropriate component MSDS. • Thoroughly clean and hose down the work area to containment area following solution preparation. • Dispose of debris and empty containers according to appropriate component MSDS. • Thoroughly clean protective equipment after use. Reuse all rinse waters for preparing treating solutions. • Provide an emergency eyewash and shower in the immediate area.
Sampling procedures	• Wear protective apparel and equipment as specified by the appropriate component MSDS. • Use sample containers approved for the application and any shipment. • Wash the outside of sample containers immediately after sampling solutions. • Wash hands thoroughly after all sampling operations
Cleaning cylinders or storage tanks	• Follow all standard precautions for vessel entry and confined space (as per provincial health and safety regulations). • Wear protective apparel and respiratory equipment as specified by the appropriate component MSDS. • Flush vessels as required to establish safe entry conditions or use an approved self-contained breathing apparatus prior to entry. • Always have a standby attendant present and observe regulations regarding lockout/tagout procedures for confined space entry. • Collect and store contaminated waste material in sealed and labeled drums. • Wash all protective equipment immediately after use. Reuse all rinse waters for preparing treating solutions. • Shower after completion of cleanup tasks.
Removing treated charges from cylinders	• Wear gauntlets during door openings and when moving loads of freshly treated wood. • Avoid breathing preservative mists. Wear an approved respirator if airborne concentrations are unknown or at or above TLVs.* • Wear impermeable** gloves.

Table 11 Safety Precautions for Personnel Working with CA-B Solutions (continued)

Objective: To ensure safe workplace practices for each activity during the treatment process.	
Activity	**Recommendations**
Handling treated lumber	• Wear impermeable** gloves, apron, boots and eye protection, if there is potential for getting splashed by CA-B solution.
Handling and maintaining contaminated equipment	• Thoroughly flush equipment with water prior to handling. Reuse all rinse waters for preparing treating solutions. • Wear impermeable** gloves, apron, boots and eye protection if there is potential for getting splashed by CA-B solution.
Welding	Welding can produce toxic fumes. In addition to the precautions for handling and maintaining contaminated equipment: • Obtain the specific approval of the plant supervisor before welding. Follow all standard precautions for vessel entry and confined space (as per provincial health and safety regulations). • Block or disconnect lines from tanks before initiating welding operations. • Completely drain and thoroughly rinse tanks or lines prior to welding operations. • Ensure that equipment is completely dry from cleaning solvent residues. • Wear a respirator or provide effective, local exhaust ventilation during welding to prevent potential exposure to toxic fumes. • Assure good general ventilation of the work area. • Comply with all additional provincial workplace safety rules.

* An initial workplace monitoring program will have determined the need for respirator use. The results of the program are assumed to be indicative of conditions in subsequent facility operations, unless procedural or design changes have occurred.

** Heavy-duty, lined polyvinyl chloride, vinyl-coated, neoprene, NBR or rubber.

Note that the pesticide label may prescribe additional or more stringent requirements for personnel protective equipment for various activities than is indicated here. These label requirements must be followed.

7 Design Recommendations

The tables in this section deal with good design features specifically relating to CA-B plants. These recommendations must be used in conjunction with the basic design criteria listed in Part I, Chapter A - General Background Information and Recommendations, section 7. Their objectives are:

- to prevent or reduce direct contact of personnel with CA-B chemicals;
- to reduce releases to the environment;
- to enable prompt response to abnormal events to ensure worker safety and environmental protection.

Tables 12 to 16 outline these recommendations. Figure 6 in Chapter A presents an overview of the following sections and may be cross-referenced in each subject area.

Table 12 Recommended Design Features For Chemical Storage Areas

(See also Part I, Chapter A - General Background Information and Recommendations)

Delivery format	Design feature	Recommendations
Bulk CA-B liquids: • Concentrate • Working solutions • Contaminated surface runoff • Drip return	**Chemical tank unloading area**	• Unloading area should be contained with impermeable floors and sump. Spill catchment materials should be stored in vicinity.
	Chemical unloading pump and backflow prevention	• Use backflow prevention and locking caps on chemical delivery lines.
	Fresh-water supply line	• Install backflow preventers on all incoming water lines. • Use top entry for water lines to tanks as secondary backflow prevention. • Waterlines must comply to local codes.
	Emergency response	• Provide accessible storage for spill-response equipment, absorbents and personnel equipment.

Table 13 Recommended Design Features For Chemical Mixing Systems

(See also Part I, Chapter A - General Background Information and Recommendations)

Chemical form	Design feature	Recommendations
CA-B bulk concentrate	**Location/shelter**	• Locate in a contained, enclosed, heated area, particularly if subfreezing temperatures are encountered during operation.
	Spill prevention	• Interlock high-level alarms to mix and process systems to prevent tank overflow. • Provide for safe usage of drummed materials (equipment, pumps, enclosures, etc.) with minimum worker exposure. • Provide all applicable features for “spill containment of bulk liquids”(Chemical Storage Area, Table 12).

Table 14 Recommended Design Features for Treatment Process Systems

(See also Part I, Chapter A - General Background Information and Recommendations)

Design feature	Recommendations
Ventilation	• Provide adequate routine and emergency ventilation to control preservative component vapour levels in all work areas.
Process emissions to air	• Vent all air emissions (including tank vents and vacuum pump exhausts) to the building exterior with appropriate safeguards to prevent escape of liquids to the environment.

Table 15 Recommended Design Features For Freshly Treated Wood Drip Areas

(See also Part I, Chapter A - General Background Information and Recommendations)

Design feature	Recommendations
Drip Protection	• Provide for sufficient contained and roofed storage area for freshly treated wood prior to application of accelerated or ambient fixation processes. • Provide completely contained and roofed drip area for material undergoing fixation at ambient conditions.
Fixation	• Where freshly treated wood is stored prior to removal to an accelerated fixation unit or a protected, contained storage area for fixation under ambient conditions, a paved (impermeable), contained and roofed area should be provided for such storage. • The storage area for fixation under ambient conditions should be paved (impermeable), contained and roofed, with provisions for recovery of drips and any infiltrating precipitation. • Provide the fixation chamber with an impermeable floor for collection of drips and a drip-collection system. • Provide adequate contained drippage area for all freshly treated wood. • Drippage should be complete before wood is moved to ambient or accelerated fixation (as determined by consideration of wood types, treatment processes, operational practices and other relevant factors).

Table 16 Recommended Design Features For Dry Treated Wood Storage Areas

(See also Part I, Chapter A - General Background Information and Recommendations)

Design feature	Recommendation
Storage areas	• Where practical, store all dry treated wood under roof or wrap. • Segregate treated wood storage areas from other storage areas and segregate contaminated from uncontaminated runoff water to minimize the need for water treatment and/or recycling.

8 Operational Recommendations

The recommendations for good operating practice listed in this section must be used in conjunction with those in Part I, Chapter A - General Background Information and Recommendations, section 8.

The objectives are to protect both workers and the environment from harmful exposure to CA-B solutions.

Table 17 Recommended General Operating Practices For CA-B Pressure Treatments

(See also Part I, Chapter A - General Background Information and Recommendations)

Operation	Recommendations
Procedures	• Prepare (and have readily available) explicit written instructions for all aspects of chemical use, facility operation, maintenance and emergency response. • Identify and communicate precautions for all other on-site handlers of treated wood (including quality control personnel, sorters and transporters).

Table 18 Recommended Operating Practices For Chemical Handling And Storage

(See also Part I, Chapter A - General Background Information and Recommendations)

Operation	Recommendations
Preservative concentrates	• Following complete rinsing, dispose of unusable containers only in an approved manner. • Sound containers may be reused for storage of wastes until disposal. • Label storage tanks with the identification of contents by chemical and concentration. • Post safety placards, with fire or spill emergency response procedures, personnel safety precautions and first aid procedures in prominent locations. • Restrict access of unauthorized personnel to the plant.

Table 19 Recommended Operating Practices For Freshly Treated Wood

(See also Part I, Chapter A - General Background Information and Recommendations)

Operation	Recommendations
Treatment process	• Apply sufficient final vacuum to remove as much excess liquid from the wood as possible.
Fixation	• Fixation is time- and temperature-related. • Aboveground treated material will be mostly fixed in the cylinder; more heavily treated material will require either accelerated fixation or ambient temperature fixation. Fixation times will depend on level of treatment. • Accelerated fixation is to be preferred to fixation under ambient conditions. • Where interim storage is necessary, freshly treated wood should be held in a protected, contained area, until moved into an accelerated fixation unit or to a protected area used for ambient fixation. • Fixation should be verified before removing material from protected contained areas. • Note: little is known about the leachability and fixation characteristics of freshly treated wood and no accepted test method had been identified at the time of the issuance of this TRD. The plant therefore must take all possible precautions to minimize drippage from the charge and hold freshly treated material for at least 24 hours on a protected drip pad and preferably longer, prior to removing it to an unprotected area.

9 Process Emissions and Disposal

9.1 Control, Treatment and Disposal

Potential process emission sources at CA-B wood preservation facilities were described in section 5.2 and Figure 3. The main categories of process wastes or emissions, which may be encountered at CA-B facilities, and recommended disposal methods, are presented in Table 18 of the general chapter (Chapter A).

9.2 Liquids Containing CA-B

Liquid Process Wastes

Liquid process wastes should not be discharged from CA-B plants. Liquid solutions (such as drips and washwaters) containing CA-B are routinely collected and reused as make-up waters in preparing new treatment solutions. If unusual circumstances (such as prolonged plant shutdown) prevent on-site reuse, transportation to another CA-B facility should be arranged. Disposal of process liquids should be considered only as a last alternative.

If disposal is unavoidable, specific approval must be obtained from the appropriate regulatory agency. If no suitable means of disposal are readily available, the solutions should be sealed in leak proof containers, labelled and stored in a secure area.

Contaminated Stormwater Runoff

Various approaches to prevent stormwater contamination can be used, including application of a proper final vacuum to remove excess treatment solution from the wood, maintaining clean solutions to minimize surface deposits, use of roofed areas for treated product storage and application of proper fixation prior to removal to storage in the open environment.

9.3 Solids with High CA-B Concentrations

For the purpose of this document, solids with CA-B include sludges from sumps and cylinders and disposable cartridge filters used to filter recycled waters. For general information on handling solid wastes, consult Part I, Chapter A - General Background Information and Recommendations, section 13.

The preferred means of disposal for CA-B-contaminated cartridge filters and wastes is solidification and burial in a secure (hydrogeologically isolated) approved, chemical landfill. It is the responsibility of the waste generator to obtain and comply with approvals required by the jurisdiction in which the disposal site/facility is located.

Solids with high concentrations of CA-B should be drained and stored in leak proof containers while awaiting disposal. Contaminated solids should be stored in a specially designated secure contained area. The area should be roofed to protect the wastes from precipitation.

9.4 Miscellaneous Solid Wastes

Miscellaneous solid wastes (e.g. empty concentrate drums or cuttings and debris from treated lumber) from CA-B wood preservation plants may be disposed of as approved by the provincial regulatory agency. The additive drums (moldicide and defoamer) should be thoroughly triple-rinsed with water prior to disposal, and the rinse water should be used for the preparation of work solutions. These drums should only be either returned to supplier if appropriate or disposed of with the appropriate disposal company.

9.5 Air Emissions

The use of an amine formulation at ambient temperature will have minimal tank emissions from normal operation. Typically no controls are necessary for ambient temperature solutions with the CA-B product. There should be no in-plant emissions from storage tank vents or vacuum pump exhausts, as these must be vented to the plant exterior with liquid release protection.

The use of heated solutions may imply some potential for amine emissions at the CA-B facility, if proper controls are not in place. Consult the chemical supplier.

Table 20 Recommended Disposal Practices For CA-B Contaminated Wastes

(See also Part I, Chapter A - General Background Information and Recommendations)

Waste category	Examples	Recommendations
Liquid CA-B solution	• CA-B concentrates • CA-B work solutions • Drips from freshly treated lumber • Washwaters	• Reuse as make-up for work solutions (standard practice at wood preservation plants)

10 Emission and Site Monitoring

Site monitoring and assessment are required at CA-B facilities, in accordance with the design and operating objectives described in this document, to verify that wood preservative chemicals are being properly managed at the site and to ensure environmental and worker health protection. Assessment records also will allow orderly site decommissioning if a plant is shut down.

Environmental monitoring requirements for most CA-B facilities would normally be developed in consultation with the appropriate provincial environmental regulatory agency. Additional consultation would be required with Environment Canada if a facility has a potential to impact on federally managed land or if a facility is located adjacent to waters frequented by fish). Worker health monitoring requirements would be developed in consultation with a provincial workers' compensation board and/or department of labour.

A monitoring program must be designed to ensure that there are adequate monitoring sites and that the frequency of monitoring and the detection limits of the preservative constituents are defined. The appropriate components of a site environmental and worker exposure monitoring program are suggested in Table 8 of Part I, Chapter A - General Background Information and Recommendations.

11 Transportation of CA-B Components, Solutions and Wastes

The transportation of CA-B concentrate solutions and CA-B wastes are regulated under the federal *Transportation of Dangerous Goods* (TDG) *Act*. The act does not apply to the transportation of treated wood or treated wood wastes. The regulation of intraprovincial movement of dangerous goods is a provincial responsibility.

The stipulated transportation procedures are abstracted in Part I, Chapter A - General Background Information and Recommendations, section 11.

12 Spill and Fire Contingency Planning

Preparedness for emergencies is essential in any wood preservation plant. Hence, facilities using CA-B should prepare and have readily available detailed contingency plans to ensure that response to spills and fires is quick, safe and effective. It is recommended that the individual facility plans be filed with the authorities having jurisdiction.

12.1 Spill Contingency Planning

In addition to the recommendations in the corresponding section 12.1 of Part I, Chapter A - General Background Information and Recommendations, the following recommendations apply to CA-B facilities if a spill occurs:

- Immediately put on all appropriate personal protective equipment as outlined in the MSDS for the product;
- Remove all unauthorized personnel from the scene of the spill;
- Spills and leaks outside of containment –
    - Concentrate
        - Use absorbent material such as vermiculite, kitty litter or absorbent pads (not sawdust)
        - Use pump to pick up liquid
    - Treating solution
        - Use absorbent material such as vermiculite, kitty litter or absorbent pads (not sawdust)
        - Use pump to pick up liquid
- If tanks other than normal work tanks are used for salvage purposes, assure compatibility of materials (e.g. do not use galvanized or aluminum tanks).

12.2 Fire Contingency Planning

In addition to the recommendations in the corresponding section 12.2 of Part I, Chapter A - General Background Information and Recommendations, the following recommendations apply to CA-B facilities in case of a fire.

CA-B is not flammable, but precautions should be taken in the event that a fire occurs. Toxic gases could be released from the preservative materials if these are excessively heated.

Use an extinguishing agent appropriate for the type of fire encountered. Consult local fire department.

> **Extinguishing agents:** Use water, dry chemical or other common extinguishing media.
> **Firefighting procedures**: Fire from a separate fuel source may be intense enough to cause thermal decomposition releasing toxic fumes and/or gases. Wear complete fire service protective equipment, including full-face NIOSH- and NFPA-approved self-containing breathing apparatus.

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CHAPTER I

Inorganic Boron (Borate) Wood Preservation Facilities

Preservative-specific Information and Recommendations

This chapter must be used in conjunction with Part I -
General Background Information and Recommendations.

Contents

List of tables

Figure

1 Production and Use

Inorganic boron (borate) wood preservation chemicals are generally sold as Disodium octaborate tetrahydrate under the trade name TIM-BOR®, which is supplied in powder form. The preparation of treating solutions, which range from 1 to 5%, involves blending of the powder with requisite amounts of water. Solutions are stored in mild steel tanks and applied to wood under pressure until a predetermined amount has been absorbed by the wood in accordance with applicable standards (1). On removal of the wood from the pressure vessel, treated wood is stored in a roofed area or under wrap. It remains wrapped at all times until final use. It should be noted that borates are water soluble, and treated wood is suitable only for applications where the wood is not in contact with the ground and is continuously protected from free water.

Although borates have been used for over 50 years to protect wood by diffusion processes for interior applications, it has seen a recent re-emergence in North America for the pressure treatment of lumber and timber for interior construction. Currently there are several impregnation plants operating in Canada that use borates (2). Table 1 presents basic information on use of borates in Canada.

Table 1: Borate Usage in Canada

Feature	Characteristics
Delivery format	Multi-wall paper bags with a polyethylene moisture-resistant barrier, 50 kg net weight
Chemical composition	
Sodium oxide (Na_20)	14.7%
Boric oxide (B_20_3)	67.1%
Water of crystallization (H_20)	18.2%
Equivalent boron (B)	20.5%
Manufacturer	United States Borax and Chemical Corp., Los Angeles, California
Suppliers	Arch Wood Protection Canada Corp., Mississauga, Ontario Timber Specialties Ltd., Campbellville, Ontario
Concentration of work solutions	1% to 5%
Typical preservative retention in treated wood (as B_20_3)	2.7 kg/m^3
Major products treated in Canada	Lumber for interior construction in residential and institutional/industrial buildings

2 Physical and Chemical Properties

The chemical composition of the borates used for wood treatments was chosen to enable appropriate impregnation of wood with an active ingredient that is effective in protecting wood against fungi, termites and other wood-boring insects.

Table 2 Physical and Chemical Properties of Borate Wood Preservatives (3)

Identification		
Common synonyms: Borate, TIM-BOR®, Disodium octaborate tetrahydrate, Polybor 3	**Manufacturer**: U.S. Borax **Suppliers**: Arch Wood Protection, Timber Specialties **Chemical formula**: $Na_2B_80_{13}.4H_20$ WHMIS classification: Class D, Division 2A	
Transportation and storage information		
Shipping state: powder **Concentration**: approximately 82%	**Storage temperature**: ambient **Special sensitivity**: Moisture (caking) **Containers**: bags for powder; mild steel for solutions	**TDG/UN**: Disodium octaborate tetrahydrate is not regulated.
Physical and chemical properties		
Physical state: solid **Solubility**: 9.7% @ 20ºC 34.4% @ 50ºC **pH @ 20º**: 8.3 (3.0% solution) 7.6 (10.0% solution)	**Appearance**: white, odourless powder **Melting point**: 815ºC **Vapour pressure**: negligible @ 20ºC **Molecular weight**: 412.52	
Hazard Data		
Fire No general hazard, not flammable, combustible or explosive. Product is a fire retardant. **Extinguishing media**: Compatible with all extinguishing media.	**Stability:** Stable **Reactivity:** Reacts with strong reducing agents, such as metal hydrides or alkali metals; will generate hydrogen gas, which could create an explosive hazard **Hazardous decomposition** None	

3 Environmental Effects

3.1 Distribution in the Natural Environment

Borate (B) is the element in disodium octaborate tetrahydrate that is used by convention to report ecological effects of borate products. It occurs naturally in rock, soils, and fresh and salt water. Table 3 presents natural background levels (4).

Table 3 Typical Background Levels of Boron

Medium	Range	Common level
Soils	2 to 100 ppm	< 10 ppm
Rock	5 to 100 ppm	10 ppm
Fresh water	< 0.01 to 1.5 ppm	
Sea water	0.5 to 9.6 ppm	4.6 ppm

3.2 Aquatic Toxicity

The toxicity of boron compounds is generally expressed in terms of boron itself. To convert disodium octaborate tetrahydrate into the equivalent boron, a multiplying factor of 0.2096 is applicable.

Table 4 Toxicity of Sodium Tetraborate to Fish

Seawater (5):
Dab (*Limanda limanda*): 96 hr LC_{50} = 74 µg B/L
Freshwater (6):
Rainbow trout (*Salmo gairdneri*): embryo/larval stage 24-day LC_{50} = 88 µg B/L 32-day LC_{50} = 54 µg B/L Goldfish (C*arassius auratus*): embryo/larval stage 7-day LC_{50} = 65 µg B/L 3-day LC_{50} = 71 µg B/L

The Canadian drinking water guideline, i.e. the “Interim Maximum Acceptable Concentration” for boron is currently set at 5 mg B/L.

4 Human Health Concerns

Boron is a naturally ubiquitous element to which humans are commonly exposed. The daily diet contains low levels of boron. However, in industrial settings appropriate safeguards (see section 6) need to be implemented to avoid overexposure.

Acute toxicity (Disodium octaborate tetrahydrate)

Ingestion: LD_{50} (rats): 2 550 mg/kg
Skin/dermal: LD_{50} (rabbits): <2 000 mg/kg
Inhalation: LD_{50} (rats): <2.0 mg/kg
It is not a skin irritant or skin sensitizer.
Eye irritation: produces mild eye irritation in Draize test on rabbits.

Chronic toxicity

Animal feeding studies in rat, mice and dogs have shown effects on fertility and testes (7). Available data (rat) suggest that the fetal animal is more sensitive to boron toxicity than the maternal animal.

There is no evidence of carcinogenicity in mice and no mutagenic effects were observed in a number of tests using boric acid (8).

Human epidemiological studies show no increase in pulmonary disease in occupational populations with chronic exposures to boric acid dust and sodium borate dust. A study under conditions of normal occupational exposure to borate dust indicated no effect on fertility (9): however, the study is considered to have significant limitations. A study on Russian workers exposed to vapours and aerosols of boron salts showed low sperm counts and decreased sperm motility (10). The Reproductive Health Team of National Institute for Occupational Safety and Health (NIOSH) scientists under the U.S. National Occupational Research Agenda (NORA) is currently focusing on several primary data gaps: these include the lack of studies of effects of high priority reproductive toxicants on humans and a need to understand the extent of occupational exposure to these high priority substances. One of the toxicants under study is boron, and the scientists are investigating how boron relates to the issue of male fertility and what level of workplace exposure to this toxicant is safe. Dr. Wendie Robbins of UCLA is conducting a NIOSH-funded study of over 1000 boron-exposed workers in China. Preliminary results indicate that 9.6% of boron-exposed workers reported a history of infertility, compared with 4.8% of unexposed workers. Laboratory measurements of semen quality, blood hormones and boron levels will contribute to an assessment of safe exposure levels for men who work with boron (11).

5 Description of Preservative Application and Potential Chemical Discharges at Borate Wood Preservation Facilities

5.1 Description of Process

The impregnation of borates into wood is carried out in pressure-treatment plants with equipment and process conditions similar to those used with CCA. Process conditions and treatment results are described in CAN/CSA 080.34 (1).

The treating chemical is purchased as a solid in 50 kg bags. Indoor dry storage is recommended to prevent caking. Usually, a treatment solution is prepared by direct mixing with water in a suitable mild steel tank. Solution concentrations range from 1 to 5% and depend on the wood species, size of material, permeability and retentions to be achieved.

A standard full-cell impregnation process is generally applied in a conventional mild steel vessel (pressure cylinder). This entails an initial vacuum, fill of the cylinder while the vacuum is maintained, and then the application of pressure. Unlike when treating with other preservatives, the moisture of the wood charge is preferably elevated (around 30%) and a final vacuum, if used at all, is kept short and is used to produce dry surfaces. Once the treated wood has been removed from the impregnation vessel, it has to be kept under a roof or a wrap until it is used in an interior location. Exposure to precipitation or running water can deplete the treatment chemical from the wood. Diffusion of the chemical into the wood carries on in the presence of adequate wood moisture after the pressure process has been terminated.

5.2 Potential Chemical Discharges

Borate wood preservation plant designs and operational practices do vary and within each plant there are various potential emission sources that may affect the adjacent environment and/or worker health. The potential sources and types of releases are illustrated in Figure 1.

Liquid discharges

The borate process uses water as a solvent. Therefore, drippage collected on the pad or rainwater collected in the process areas can be reused within the process. The process technology and economics have led the borate wood preservation industry to use closed treatment systems that contain, collect and reuse the chemical mixture to the greatest possible extent. Primary elements that may be used for borate containment and recycling are essentially the same as are used in pressure treatment facilities applying other waterborne preservatives.

These elements include:

- paved containment surfaces and dyking of major process components including the cylinder and tankage in a roofed facility.

- containment surfaces for chemical drips from treated wood on the cylinder discharging track, that is, in the freshly treated wood storage area and wrapping areas that are roofed.
- a collection sump to receive residual preservative from the cylinder (following the treatment cycle) and the accumulated contaminated runoff from other containment surfaces.

Contaminated liquids entering the sump are pumped through cartridge filters to remove dust and wood debris. The filtered solution is stored in a holding tank and returned to the process as make-up water for preparing fresh working solution for subsequent charges.

Under normal operating practices, liquid discharges from a borate treatment facility are confined to liquids that are not contained and reused within the process. For example, stormwater runoff from unpaved and unroofed treated-product storage areas might be the most common liquid from a borate treatment facility. The quantity of borate in such waters depends on many factors, such as quantity of precipitation, the degree of wrapping prior to the precipitation event, and soil characteristics of the storage yard. Uncontained liquid releases other than stormwater are generally confined to yard soils. Potential for groundwater contamination exists in locations where drip pads are not used in discharging areas or where the pad areas are inadequate to hold the treated wood until wrapping is accomplished.

Solid Wastes

Solid waste generation at borate facilities should be minimal. During normal operating conditions, solid waste is limited to cartridge filters that are used for dust and debris removal from recycled water and to the debris and sludges that are periodically removed from the sump, cylinder and tanks. Treated wood, such as stickers, cut-offs or broken product, is another source of solid wastes.

Air Emissions

Potential sources of air emissions include mists from vacuum pump exhausts, cylinder doors and tank vents. At this time, no air emission monitoring data are available from borate treatment plants.

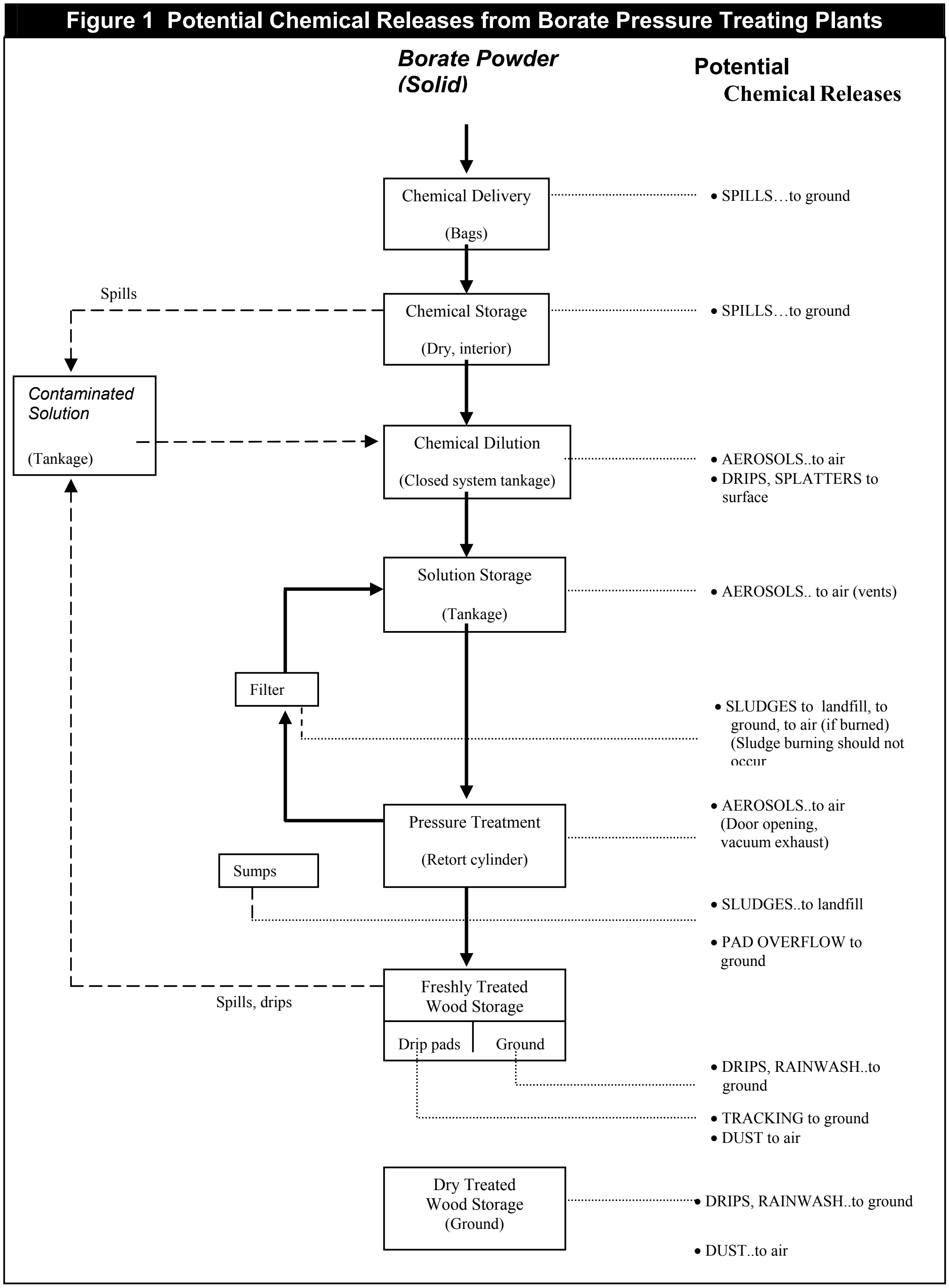
5.3 Potential Effects

The actual impact of any emission depends on many factors, including the location of the wood preservation facility relative to ground and surface waters, the amount associated with the releases and contingency measures in place at the facility.

Borates have only been recently introduced into Canada and no environmental assessments from plants are available as of January 2004. It is not expected that environmental and worker health effects would be caused in facilities using normal operating practices. Although borates have relatively low fish toxicity, contamination of water bodies must be prevented. Boron is an essential micronutrient for plants, but it can be harmful in large quantities via absorption through plant roots.

Borates also have a low vapour pressure. Treatments under ambient temperature would not represent substantial air quality issues. With elevated process conditions, vapour generation would be increased. However, any air releases would likely be in the form of localized mists and the effect of a facility on the surrounding environment is expected to be of little consequence.

Figure 1 Potential Chemical Releases from Borate Pressure Treating Plants



6 Personnel Protection

For general comments on personnel exposure and protection refer to Part I, Chapter A - General Background Information and Recommendations, section 5. The general precautions and personal hygiene measures applicable to the use of borates are contained in Table 1 of Chapter A.

6.1 First Aid

Table 5 First Aid for Exposure to Borate

Exposure	First action	Second action
Eye contact	• Flush eyes with water for 15 minutes.	• If irritation persists for more than 30 minutes, seek medical attention.
Skin contact	▪ Wash with water. ▪ Remove contaminated clothing.	
Inhalation	• If nose and throat irritation are experienced, remove person to fresh air.	
Ingestion	• Induce vomiting and drink large amounts of water or milk.	• Seek medical assistance.
Chronic symptoms requiring medical attention	• There is no information on any adverse chronic effects of industrial use of borates.	

Disodium octaborate tetrahydrate is not considered an acute poison. After ingestion or absorption into the bloodstream of large amounts (15 g or more), symptoms may appear after 24 to 72 hours. Borates are readily dissipated through the urine (70% in the first 24 hours).

6.2 Regulatory Controls

Specific limits for worker protection are generally found in provincial regulations. Most of the criteria are based on the threshold limit values (TLVs) and biological exposure indices recommended by the American Conference of Governmental Industrial Hygienists (ACGIH).

ACGIH refers to disodium octaborate tetrahydrate as a “Particulate Not Otherwise Classified” or “Nuisance Dust.” The ACGIH/TLV is 10 mg/m^3. The OSHA/PEL (Permissible Exposure Level) is 15 mg/m^3 respirable dust.

Safety Precautions

Table 6 Safety Precautions for Personnel Working with Borates

Objective: To ensure safe workplace practices for each activity during the process.

Activity	**Recommendations**
Unloading and storing solid preservative	• Wear coveralls and protect damaged skin. • Wear gloves (cloth gloves are adequate). • Wear dust mask. • Wear dust goggles. • Prohibit foot or vehicle traffic between delivery vehicle and bag storage. • Provide an emergency eyewash and shower near the unloading area. • Provide good local ventilation. • Avoid dust cloud formation. • Keep incompatible materials away from unloading and bag storage areas. • Keep storage area dry and covered. • Retain package integrity and handle bags on a first-in, first-out basis. • Practice good housekeeping to minimize dust generation and accumulatior
Preparing work solutions	• Wear dust mask and goggles. • Wear impermeable gloves. • Thoroughly vacuum and then wash down work area following solution preparation. • Dispose of debris and bags as per Table 17, Chapter A. • Clean protective equipment after use. • Provide an emergency eyewash and shower in immediate area.
Sampling procedures	• Wear eye protection and impermeable gloves when sampling treating solutions. • Wear impermeable gloves when taking borings from treated wood. • Wash hands thoroughly after all sampling operations.
Cleaning cylinders and storage tanks	• Follow all standard procedures for vessel entry (as per provincial health and safety regulations). • Flush vessel thoroughly and establish a safe oxygen level or wear self-contained breathing apparatus. • Wear impermeable boots, coveralls and gloves during all vessel entries. • Always have a standby attendant present. • Collect and store contaminated waste material in sealed and labelled drums • Wash all protective equipment immediately after use. • Shower after entry and ensuing cleanup tasks.
Removing charges from cylinders	• Wear gauntlets when opening doors. • Avoid breathing preservative mists. If airborne concentrations are unknown, wear an approved respirator.
Handling treated lumber	• Wear impermeable gloves. • Apply all hygiene recommendations (Part I, Chapter A - Table 1).
Handling and maintaining contaminated equipment	• Thoroughly flush equipment prior to handling, and use rinse water for preparing work solutions. • Wear impermeable equipment when there is potential for getting wet by preservative solutions.
Welding	• Comply with all provincial workplace safety rules. • Clean equipment thoroughly prior to handling.

Note: Several plants switch borates with other preservatives in a single treatment vessel. Hence, it can be expected that some contamination from these alternative preservatives is present. In this case, use the appropriate safeguards recommended for the alternative preservative (see the applicable chapter in Part II of this manual.)

Boron compounds are currently under re-evaluation at PMRA. The safety precautions outlined on the pesticide labels must be followed.

7 Design Recommendations

Use this section in conjunction with Part I Chapter A - General Background Information and Recommendations, section 7. Most design features recommended in that section apply to the use of borates. Where borates require alternative approaches, information is provided here in Tables 7 to 12.

Table 7 Recommended Design Features for Chemical Delivery Areas

Objective: To provide an off-loading area that enhances spill prevention and containment

Delivery format	Design feature	Recommendations
Borate (bags)	Off-loading area/shelter	• Provide a dry, paved off-loading area with protection from the weather, preferably near the storage area.
	Containment	• Provide an impervious pad. • Provide for containment of worst event spill of borate solids (e.g. from dropped pallet load). • Provide for containment with smooth surfaces for easy cleanup.
	Area cleanup	• Provide a vacuum cleaner with a filter capable of filtering particles 1 micrometer in diameter or greater for cleanup of solids spilled during unloading and transfer operations. • Close off area to non-involved personnel during cleaning. • Wear protective equipment, i.e. a dust mask, coveralls and chemical resistant gloves.
	Access	• Locate off-loading area away from high yard traffic routes. • Restrict access during delivery.

Table 8 Recommended Design Features for Chemical Storage Areas

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 4)

Storage format	Design feature	Recommendations
Borates (bags)	**Objective:** To provide sheltered, secure, fire-protected storage of borate solids	
	Location	• Provide safe, easy access to the mixing area (design to contain and facilitate cleanup of borate dust lost during transit to the mixing area
	Shelter	• Provide storage in an enclosed, secure area, segregated from other chemicals (design to prevent infiltrating precipitation). Note: moisture leads to caking of borate. • Design to prevent fire in storage areas (use of noncombustible construction materials is preferred).
	Ventilation	• Provide adequate ventilation for both routine operating and emergency situations.
	Containment/clean-up	• Store bags in a paved, curbed or dyked area with no floor drains (or with effective, positive blocks for drains). • Design surfaces for effective cleanup of spilled material. • Provide a vacuum cleaner with a filter capable of filtering particles 1 micrometer in diameter or greater for cleanup of solids spilled during unloading and transfer operations. • Close off area to non-involved personnel during cleaning. • Wear protective equipment, i.e. a dust mask, coveralls and chemical resistant gloves.
	Security	• Provide effective security against unauthorized access.
	Emergency response	• Provide appropriate measures for rapid, effective fire control with containment of liquid firefighting residues for use in solution make-up or treatment to stipulated limits before discharge.
Bulk sludges	Location/shelter	• Locate storage in exterior or well-ventilated roofed location.
	Containment	• Store in sealed and labelled drums. • Locate in a containment area with impermeable, cleanable floors. • Provide adequate containment capacity for a worst event spill. • Block any drains in the containment area; design to collect infiltrating precipitation for treatment to applicable limits prior to discharge (if contaminated).
	Handling	• Provide transfer equipment for clean, safe sludge handling with minimum worker exposure.
	Security	• Provide effective security against unauthorized access and/or release of tank contents.
Bulk liquids • Borate solution storage • Contaminated surface runoff • Drip return		Objectives and recommendations as per Part I, Chapter A, Table 4.

Table 9 Recommended Design Features for Chemical Mixing Systems

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 5)

Configuration	▪ Use permanent/closed system with rigid piping. ▪ Provide good ventilation during bag opening/emptying operation.
Location/shelter	▪ Locate in a contained, dry sheltered area. ▪ Provide protection against freezing.
Solids handling	▪ Provide a dry, paved area for bag opening. ▪ Provide a vacuum cleaner for effective cleanup of dusts.
Backflow prevention	▪ Provide for effective backflow prevention for all water delivery lines.

Table 10 Recommended Design Features for Treatment Process Systems

Part I, Chapter A - General Background Information and Recommendations, Tables 6 and 7 apply.

Table 11 Recommended Design Features for Freshly Treated Wood Drip Areas

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 8)

Drip area	• Provide a sufficiently sized and contained area to hold all freshly treated wood until visible dripping has ceased. • Provide a sheltered, contained area to wrap treated wood prior to releasing it to an unprotected area (i.e. exposed to precipitation and uncontained ground).

Table 12 Recommended Design Features for Treated Wood Storage Areas

(Use in conjunction with Part I, Chapter A - General Background Information and Recommendations, Table 9)

Treated wood, unprotected from precipitation and running water will leach: ensure that all treated wood is wrapped prior to release into open storage.

8 Operational Recommendations

Use this section in conjunction with Part I, Chapter A - General Background Information and Recommendations, section 8.

Most operational recommendations in that section apply to the use of borates. Where borates require alternative approaches, information is provided here in Tables 13 to 16.

Table 13 Recommended General Practices for Operating Borate Wood Preservation Facilities

Part A – General Background Information and Recommendations, Table 10 applies.

Table 14 Recommended Operating Practices for Chemical Handling and Storage

Part A – General Background Information and Recommendations, Table 11 applies.

Table 15 Recommended Operating Practices for Borate Process Systems

Part A – General Background Information and Recommendations, Table 12 applies.

- It is recommended that no or only a slight final vacuum be applied.
- All treated wood must be protected from precipitation until final installation.

Table 16 Recommended Operating Practices for Maintenance, Cleanout and Shutdown of Borate Treatment Systems

Part I, Chapter A - General Background Information and Recommendations, Table 13 applies.

9 Process Emissions

The wood preservation process generates liquid and solid wastes and also emissions to the air (Fig. 1). A variety of measures are available for control, treatment and disposal of process wastes and emissions and approaches may have to be tailored for individual facilities.

10 Emission and Site Monitoring

Site monitoring and assessment are recommended at borate facilities in accordance with the design and operating objectives described in this document, to verify that wood preservative chemicals are properly managed at the site and to ensure environmental and worker health protection. Environmental monitoring requirements would normally be developed in consultation with provincial regulatory agencies and, where applicable, Environment Canada. However, worker health monitoring programs may be developed in consultation with a provincial workers' compensation board and/or department of labour.

A monitoring program needs to ensure that adequate monitoring sites and frequencies are selected and that the preservation constituents, detection levels and quality control are defined. The appropriate components of a site and worker exposure monitoring program are contained in Part I, Chapter A - General Background Information and Recommendations, Tables 14 and 15.

11 Transportation of Preservative Solids, Solutions and Wastes

General information is provided in section 11 of Part I, Chapter A.

Disodium octaborate tetrahydrate is not regulated under the *Transport of Dangerous Goods Act*. It does not have a UN product identification number and is not regulated under international rail, road, water or air transportation regulations. Under the U.S. Department of Transportation, it is not classified and, therefore, not considered a hazardous material/substance.

12 Spill and Fire Contingency Planning

Preparedness for emergencies is essential in any wood preservation plant. Hence, facilities using borates should prepare and have readily available detailed contingency plans to ensure that response to spills and fires is quick, safe and effective.

Regular drills will enhance a plant's preparedness.

No special requirements exist for borates, the basic spill and fire planning components are listed in Part I, Chapter A, section 12.

13 Solid Wastes and Sludges

The manufacture of treated wood generates solid wastes and sludges that require careful handling and eventual disposal (see recommendations in Table 17 of Part I, Chapter A). Preservative- and operation-specific characteristics determine the type of wastes that may be generated and the procedures to handle them. Wastes may include wood debris, treated or untreated, such as cut offs and broken sections of product, as well as contaminated filters, wraps, solution precipitates and sludges periodically removed from sumps, cylinders, tanks and containment areas. Other wastes are contaminated soils. The principles of waste minimization, and the recovery and reuse of preservatives should be practiced to the utmost to limit the volumes of waste at the plant.

A provisional code of practice for the management of post-use treated wood has been prepared by the Hazardous Waste Task Group of the Canadian Council of Ministers of the Environment (12). This would also apply to treated waste wood from borate preservation plants.

Consult with the provincial and local authorities on the acceptable disposal method for materials containing borates. Borates are generally considered nonhazardous waste when spilled or disposed of. When spilled into water, advise local water authorities that none of the affected water should be used for irrigation or for potable water until natural dilution returns to its normal environmental background level.

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Part III

Appendices

Appendix I

Legislative Summary

The following list provides examples of federal and provincial acts that may be applicable to the use, transportation and disposal of wood preservatives. Acts (and their associated regulations) may change from time to time, and as such, it is recommended that the official versions of all acts and regulations be consulted. It is also recommended that all jurisdictions that have potential authority over a project are consulted in association with wood preservation activities.

Federal Acts

1) *Fisheries Act* (1985)
2) *Pest Control Products Act* (2002)
3) *Transportation of Dangerous Goods Act* (1992)
4) *Canadian Environmental Protection Act* (1999)
5) *Hazardous Products Act* (1985)

Provincial Acts

Alberta
1) *Water Act*
2) *Clean Air Act*
3) *Environmental Protection and Enhancement Act*

British Columbia
1) *Waste Management Act*
2) *Environmental Management Act*
3) *Pesticides Control Act*
4) *Workers' Compensation Act*

Manitoba
1) *Dangerous Goods Handling and Transportation Act*
2) *Environment Act*

New Brunswick
Clean Environment Act

Newfoundland
Department of Environment Act

Nova Scotia
1) *Environmental Protection Act*, SNS, 1973
2) *Dangerous Goods and Hazardous Wastes Management Act*, SNS, 1986

Ontario
1) *Dangerous Goods Transportation Act*
2) *Environmental Protection Act*
3) *Health Protection and Promotion Act*
4) *Lakes and Rivers Improvement Act*

5) *Ontario Water Resources Act*
6) *Pesticides Act*
7) *Occupational Health and Safety Act*

Quebec
1) *Loi sur la qualité de l'environnement* (Environmental Quality Act)
2) *Loi sur la santé et la sécurité du travail* (Occupational Health and Safety Act)
3) *Code de la sécurité routière* (Road Safety Code)

Saskatchewan
1) *Environmental Management and Protection Act* (EMPA)
2) *Clean Air Act* (CAA)