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INDUSTRIAL HYGIENE SURVEYS OF OCCUPATIONAL EXPOSURE TO WOOD PRESERVATIVE CHEMICALS

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
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Alan S. Todd, M.S.
Cynthia Y. Timbie, M.S.
Stewart-Todd Associates, Inc.
Wayne, Pennsylvania 19087

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NIOSH Project Officer: James L. Oser
Principal Investigator: Alan S. Todd

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PREFACE

The Occupational Safety and Health Act of 1970 emphasizes the need to protect the health and safety of workers occupationally exposed to a wide variety of potential hazards. The National Institute for Occupational Safety and Health (NIOSH) implemented this study to evaluate exposures to wood treatment chemicals in the wood processing and wood preservatives manufacturing plants in response to the 1978 EPA Rebuttable Presumption Against Reregistration (RPAR) of these materials. This technical report on occupational health hazard assessment is a result of field, literature, and laboratory studies. It addresses the classes of materials presently in use in the wood treating industry for long-term preservation purposes. The applications of wood preservative chemicals as temporary treatment for molds and sap stain control were not evaluated in the study because they do not typically occur at wood treating plants or require the same process techniques.

ABSTRACT

Industrial hygiene studies were conducted at eleven wood treating plants and two manufacturing operations as part of an industry-wide evaluation of worker exposure to wood preservative chemicals. The purpose of these field studies was to evaluate airborne exposure levels and characterize existing work practices and other methods of exposure control.

The wood preservative industry is comprised of over 1,000 plants in the United States with the majority employing less than ten workers in wood treatment processing. Approximately 500 plants are members of industrial trade associations: American Wood Preservers Institute (AWPI) and American Wood-Preservers' Association (AWPA), and others. It is estimated that about ten major plants produce 50% of the total treated wood in the United States.

The report presents the findings from preliminary walk-through and in-depth industrial hygiene studies of the various wood preservative processes.

In general, employee exposures to preservative chemicals during wood treatment were well below the current applicable occupational standards. Short-term peak exposures occur during critical tasks, such as cylinder opening and unloading, when filling non-pressure tanks with hot PCP oil solutions, and during inspection and sampling of treated wood. The exposure levels measured were all well below current guidelines for significant health risk.

The personal sampling data generated from the comprehensive study is basically in agreement with exposure findings of past surveys conducted by the wood treatment industry and Health Hazard Evaluations done by NIOSH.

The study emphasizes the need for improved work practices to further minimize worker exposure and contact with recognized toxic chemicals during emergency spills, non-routine situations or critical process tasks. Recommendations are given for personal protective equipment, modified work practices, and medical surveillance programs.

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The companies and trade associations within the wood preservative industry cooperated extensively with this project. In addition to the investigative team, substantial contributions were made by Loren Dorman, AWPI, Don Rapp, Dow Chemical, and Charles Flickinger, Koppers Company.

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INTRODUCTION

The wood preservation treatment industry, on a national basis, processed an estimated 350,970,000 cubic feet of wood products in 1979. There is limited occupational exposure data, however, on workers routinely using the water and oil-borne preservative chemicals in spite of their toxicity. This is primarily because the employee groups at individual plants are small. In the last century, most of the commercial operations were family-owned. Since World War II, greater automation, while not dramatically changing processes or materials, has generally increased plant size, capacity, and capital requirements. Consequently, larger companies now process a majority of the total wood treated in the United States.

The National Institute for Occupational Safety and Health, as part of its responsibility for research in areas of occupational concern, contracted with Stewart-Todd Associates to study and evaluate occupational exposures and health risk in the wood treatment industry. This project was funded as the first agent of NIOSH Contract No. 210-78-0060, "Industrial Hygiene Assessment of New Agents - III."

Eleven treatment plants and two preservative chemical manufacturing operations were surveyed during the preliminary phase of the study. In the preliminary field survey phase of the study, only one plant site where the waterborne salt mixtures are manufactured was included. The increasing use of these types of wood preservative chemicals would normally warrant additional follow-up comprehensive surveys of these facilities. However, there are only three such installations in the United States and the total numbers of workers did not justify follow-up work in this segment of the preservative industry.

The facilities were selected on the basis of treatment process, preservative chemicals in use, geographical distribution, size of work force, and other parameters. General area samples were taken to evaluate different air sampling methods, define analytical limitations, and obtain a range of potential exposure levels during critical short-term tasks. Employee training and general occupational education efforts were evaluated along with historical data and experience from safety and health monitoring. These initial surveys provided the basis for the comprehensive phase of the study in which personal exposure monitoring was conducted at four treatment plants.

This report presents the following factors:

1. A detailed description of treatment processes and chemicals.

2. Documentation of current work practice and engineering controls.

3. An evaluation of NIOSH and alternate sampling and analytical procedures.

4. Documentation of typical inhalation exposure levels for various treatment processes.

In reviewing analytical parameters for the creosote preservative mixtures, various options were considered for determining exposure risk from airborne or contacted materials. Of primary concern with these types of hydrocarbon materials are the polynuclear aromatic compounds. Elaborate individual polynuclear analysis was considered for a variety of creosote mixtures utilized in the industry and personal samples taken in the field. However, it was not done for two basic reasons. First, the data available from elaborate research studies on single or multiple polynuclear 3-6 ring compounds indicate that additional specific analysis does not provide insight in ranking the biological activity of mixtures. This results from the fact that the complex mixtures contain some known carcinogens such as benz alpha pyrene (BAP), other materials which are co-carcinogens, accelerators, and some 3, 4 and 5-ring compounds which are inhibitors of the carcinogenic process.

In addition, the high cost of performing the elaborate or even simple compound analysis for BAP on the variety of samples taken did not appear warranted based on the additional information it would provide on potential health risk to the materials. We have treated creosote as though it had the same carcinogenic potential as coal tar pitch volatiles in coking oven operations. This may not be correct but it permits a conservative approach to health risk control so long as it does not place undue burden on the wood preservative chemical manufacturers or users. In evaluating exposures to the water-borne materials, one of the primary concerns was skin absorption and/or incidental ingestion resulting from hand contamination during handling of treated wood.

The procedures utilized to determine surface contamination do not reflect quantitatively an index of personal exposure risk but provide an indication of process steps and tasks of greatest occupational concern. Recommendations to minimize these sources of exposure risk are primarily oriented to work practice modifications rather than specific engineering efforts per se. A number of engineering alternatives are presented for future plant modifications to make them cost effective in addition to reducing the time or frequency of the most critical exposures of concern.

Also considered in the study was elaborate analysis of the dioxin contaminants in pentachlorophenol (PCP) which pose the greatest occupational concern. Data available from recent literature, however, did not suggest it would be productive to consider this type of analysis on the personal samples unless they were significantly above the current occupational limits for PCP. The dioxin concentrations in technical grade PCP or extensively recycled preservative solutions are extremely low and, therefore, it was apparent that no additional useful information would be obtained from the costly analysis of new or used materials from the treatment plants.

Work practice and medical monitoring guidelines are presented for review by both the industry and the regulatory agencies since very few of the plants surveyed or contacted had formal programs. The best answer to the RPAR concerns expressed in the EPA documents would be biological data indicating whether the alleged health effects from the wood treatment chemicals actually are occurring.

BACKGROUND

HISTORY OF WOOD PRESERVATIVE USE

Wood preservatives are chemicals or mixtures which are used to treat wood for the prevention of decay and deterioration which occurs as a result of weather, soil conditions, or the infectation by organisms such as insects, fungi, and marine borers. Several treatment chemicals and processes have been developed over the past 150 years, some of which are still in use today.

In the early 19th century, inorganic salts such as mercuric chloride, copper sulfate, and zinc chloride were used for protection against decay. Treatment was done by immersing the wood in a solution of the metal salts. Mercuric chloride was used in the first treatment plant built in the United States (Hunt and Garrett, 1967).

Coal tar creosote came into use in 1839 with the Bethell full cell pressure treatment process. The lumber or posts are enclosed in a cylinder and subjected to an initial vacuum to remove air and water from the wood cells, followed by injecting creosote into the wood under pressures varying from 125-200 pounds per square inch (PSI) at temperatures of 180-210°F. Treatment continues until the wood is saturated with creosote. Pressure is then released, the cylinder drained, and the door unbolted manually or automatically by hydraulics to permit wood removal. A short final vacuum is often utilized to remove excess creosote from the surface of the wood. This treatment method retains the maximum quantity of preservative in the wood cells (Hunt and Garrett, 1967).

The Bethell Process proved to be the most expensive treatment method available in the middle of the last century and, as a result, creosote use was not common. Its use was limited almost exclusively to marine piling applications, since it was the only preservative to provide effective protection.

Zinc chloride was initially used by the railroad industry in the 1800's for pressure treatment of crossties. Later a zinc chloride/creosote mixture was used which was as effective as the creosote treatment, but less costly. This process continued in use into the 1920's.

Two additional pressure treatment processes, the Lowry and the Reuping, were developed in the early years of this century. These are empty cell treatments in which the excess preservative is removed from the wood cells in the final vacuum phase of the process, leaving them coated rather than filled with treatment solution. Since less preservative was used, overall treatment costs were significantly reduced.

In the Lowry Process, the preservative is injected into the wood in the treatment vessel under high pressure and temperature conditions. The air naturally present in the wood is compressed in the injection process. To complete the treatment process, the pressure is released and the cylinder drained. The excess preservative is forced out of the wood by expansion of the compressed air. The only major variation in the Reuping Process is an initial application of pressure in the range of 25-75 psi prior to flooding the cylinder with creosote (Hunt and Garrett, 1967).

Solutions of creosote with crude coal tar or petroleum oils were also found to be effective and less costly alternatives for wood treating. As a result, creosote pressure applications by the empty cell method have predominated in the railroad industry since the 1920's (Ernst and Ernst, 1977).

The aqueous arsenical wood preservatives were developed in the 1930's. These chemicals consist of mixtures of compounds of bivalent copper, pentavalent arsenic, hexavalent chromium or fluorides. They typically impart a green-brown color to the wood and provide a clean paintable surface. They have only been used commercially by empty-cell pressure treatment methods in the United States.

Pentachlorophenol (PCP) has been in use since 1947 for commercial wood preservation purposes. It is applied in heavy to light petroleum carriers or solvents by both pressure and non-pressure methods.

All of these briefly described treatment chemicals are commonly used for utility poles, lumber, posts, and numerous other wood products. Few, if any railroad ties are treated with PCP or the arsenical chemicals because they impart brittleness to the wood causing excessive wear and splitting from the repeated compression and expansion.

Currently 98% of wood treating done commercially in the United States is by the pressure process (Cirilli, 1978). All pressure treatment processes are now conducted with basically similar equipment and techniques. The wood to be treated is loaded onto small rail cars (trams). These are connected in series to fit the length of the cylinder. They are pushed into the cylinder using locomotives, forklifts, or other vehicles depending upon the size of the plant. The dimensions of the cylinder can vary from 48-120 inches in diameter with total lengths of 24-180 feet (AWPA Statistics, 1978). The cylinder is sealed via a pressure-tight door, either manually (with bolts) or hydraulically, and the treatment cycle is initiated. The total length of time for treatment varies with the specific type of wood preservative solution, process, end-product use, and other factors such as wood moisture content. At the end of the cycle, the treating solution is pumped to storage tanks for later re-use, the door is opened, and a steel cable in the cylinder, which extends the full length of the tram units, is hooked to the locomotive, winch, or other power equipment which pulls the treated material on tram cars from the cylinder. The tram cars are moved to a transfer point and the wood is off-loaded and stacked for storage and/or shipment. The length of time between withdrawal from the cylinder and off-loading can vary from a few minutes to a day or more.

Most of the wood products utilized for the pressure processes must undergo some form of pretreatment to reduce moisture to a predetermined percentage. This improves the service life of the preservative chemicals and permits the wood to accept the treatment solutions in sufficient concentration to meet performance specifications (Hunt and Garrett, 1967).

Methods of pre-treatment currently in use include:

Air seasoning - conditioning of wood for waterborne arsenical or creosote treating of railroad ties.

Kiln drying - heat treating of wood for the same uses as air seasoning.

Steam and vacuum treating - steam conditioning followed by a vacuum to remove the excess moisture. It is commonly used for pretreating southern pine. It is also done during either the creosote or PCP oilborne preservative systems.

Boultonizing - this method was developed in the late 1800's and consists of heating wood under vacuum in creosote or other oil solutions to just above 212°F. This permits a rapid removal of water. It is commonly used prior to creosote or pentachlorophenol heating of soft wood such as Douglas Fir and other western pines.

Solvent Vapor drying - this process is carried out using petroleum naphtha at elevated temperatures of 270-350°F. The vaporizing of the naphtha extracts the moisture from the wood which is later separated by distillation. A vacuum is applied to remove excess naphtha and additional wood sap and water. Although in limited commercial use, when used it is usually associated with creosote treatment of crossties and timbers for the railroad industry (Fuller, et al 1977).

The full-cell treatment process is only used with the aqueous preservative chemicals and creosote when maximum preservative retention is required, such as for marine pilings, timbers, and associated uses. The empty cell processes control the quantity of preservative retained in the wood and provide a better penetration depth with a cleaner surface (Fuller, et al 1977).

More recently developed pressure treatment methods utilize volatile solvent-carriers. The Cellon[R] process is done with liquified petroleum gas (LPG) extraction followed by pressure application of PCP in Diisopropyl ether. The Dow[R] process uses methylene chloride as the solvent-carrier for pentachlorophenol. Both provide a cleaner non-oily surface lighter in color and more aesthetically acceptable.

NON-PRESSURE TREATMENT

Several types of non-pressure processes have been used to treat wood. These include: 1. brushing and spraying of woods which are typically already a part of a structure; 2. atmospheric pressure immersion processes, such as dipping, steeping, cold soaking, and thermal (hot and cold) and diffusion methods; 3. vacuum process (Hunt and Garrett, 1967). Some of these, such as the spraying and dipping processes for sap stain control with the sodium salt of PCP, were only meant to be temporary surface treatments.

Brushing and spraying were typically done with creosote, either heated or cold. Preservative chemicals in a paste form can also be brush applied. The latter was widely used for groundline treatment of poles or posts on site (Hunt and Garrett, 1967).

The thermal process is the only remaining commercial non-pressure method still in use. Pentachlorophenol in a light petroleum oil (kerosene boiling fraction) is the major preservative. Creosote has been used in the past, but now is limited to a single plant. The non-pressure treatment vessel can be a square or rectangular tank used for butt or full-length treatment of poles, or a fifty-five gallon drum or series of drums for treating fenceposts (Hunt and Garrett, 1967).

The vessel is loaded with the wood products and weights are placed on top of those materials receiving reaming full-length treatment to keep them submerged.

Hot oil (210-220°F) solution containing the preservative is pumped into the tank to cover the wood for six to eight hours. The outer sap wood cells release air under these conditions. When the hot oil is replaced with cooler (150°F) solution, a partial vacuum is produced and preservative oil penetrates the wood (Hunt and Garrett, 1967).

OTHER HISTORIC PROCESSES

The diffusion processes depend on the gradual migration of water soluble preservatives from a concentrated source into the bound water already in the wood cells. Green or freshly cut wood is covered with a concentrated strength preservative in a cream or paste form. The wood is then tightly covered with waterproof paper or other suitable vapor barrier and allowed to sit for thirty days (Hunt and Garrett, 1967).

Double diffusion processes involve the consecutive application, by either dipping or spraying, of two chemicals which will react within the wood to form a leach-resistant biocidal precipitate. While these methods have been shown to produce excellent leach-resistant products, they are no longer in commercial use (Fuller et al, 1977).

The vacuum treatment method is used to a limited extent commercially for the application of PCP preservative to millwork and exterior lumber. The lumber being treated is placed in a sealed container which does not necessarily have to be cylindrical. A partial vacuum is used to remove moisture from the wood, and the preservative solution is added until the uptake by the wood ceases. The vacuum is released and the container opened manually. The method requires much less expensive equipment than pressure methods and is,therefore, more likely to be found only at small operations, such as local lumber and millwork vendors (Hunt and Garrett, 1967).

WOOD PRESERVATIVES IN CURRENT USE

Wood treatment chemicals are classified into four subgroups:

1. Creosote or mixtures of creosote with petroleum oils or coal tar.
2. Pentachlorophenol (penta) solutions in light to heavy oils, or volatile solvents.
3. Waterborne preservatives.
4. And others.

The most recent estimated use of major chemicals is provided by the USDA EPA Preservative Chemicals RPAR Assessment Team (1981).

Most previous statistics compiled by the AWPA have been under-reported as a result of poor response to annual survey questionnaires. The Assessment Team conducted a supplemental survey to obtain missing information through contacts with non-respondents and respondents. The final production totals listed in Table 1, however, are still believed to be conservative.

Table 1. Estimated production of treated wood, 1978a/
(1,000 cubic feet)

Products	All Preservatives	Treated with Creosote Solutions	Penta	CCA/ACA/FCAP
All Products	327,486b/	154,587	79,996	92,903
Crossties and switchties c/	106,085	103,138	449	2,498
Poles	64,179	18,237	41,905	4,038
Crossarms	1,685	41	1,615	29
Piling	12,090	9,993	1,154	943
Lumber & Timbers	105,305	10,780	21,209	73,317
Fence Posts	20,028	4,584	10,983	4,461
Other productsd/	18,113	7,815	2,681	7,616

a/ Volume reported for 1977 (AWPA), plus volume reported by respondents to Assessment Team Survey, plus volume estimated for non-respondents.
b/ Creosote, Penta, and CCA/ACA/FCAP only.
c/ Includes landscape ties.
d/ Includes plywood.

Source: Phase I, NIOSH Contract No. 210-78-0060