HAZARD EVALUATION AND TECHNICAL ASSISTANCE REPORT
HETA 90-021-L2055
SUPERIOR MANUFACTURING
CINCINNATI, OHIO
JULY 1990

Hazard Evaluation and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations, and Field Studies
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Introduction

In October 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate potential health hazards resulting from exposure to formaldehyde and wood dust during particle board milling operations at Superior Manufacturing, Cincinnati, Ohio. An initial site visit was conducted on November 27, 1989 to observe the production operations and to obtain additional information on products used at this facility. On January 19, 1990 a follow-up visit was made to conduct environmental monitoring for formaldehyde and wood dust.

Background

Superior Manufacturing produces accessory items for the waterbed industry. The primary product is padded waterbed rails which are constructed of Microboard®, a Weyerhaeuser particle board product containing 85-93% wood and 5-15% urea formaldehyde resin solids. Microboard® consists of a matrix of interlocking wood fibers which may include a variety of softwoods, hardwoods, and/or western red cedar. A variety of cutting and milling operations are performed on the particle board to obtain railings of the desired dimensions. Portions of the railings are glued together with a polyvinyl acetate emulsion adhesive and are then dried in a radiofrequency (RF) oven. The final step (trothing) involves construction of the padded railing, by layering foam around the particle board and covering with upholstery material.

Environmental Evaluation

Full-shift personal breathing zone and area air monitoring for formaldehyde vapor, total particulates material (wood dust) and formaldehyde content of particulate materials was conducted on January 19, 1990, during routine production operations.

Personal breathing zone air samples were collected on the two mill operators, the cross cut saw operator and one of the trothing operators. The sampling train consisted of a pre-weighed 37 millimeter (mm), 5.0 micron (um) pore size polyvinyl chloride (PVC) filter followed by a spill-proof midget impinger containing 20 milliliters (mL) of a 1% sodium bisulfite solution. Separate air samples were collected during the morning and afternoon, to cover the entire workshift. The sampling equipment was placed in the workers' breathing zone and air was drawn through the sampling train using battery-operated pumps calibrated at 1 liter per minute (Lpm).

The particulate filters were re-weighed following sample collection to obtain total particulate concentrations, and were then analyzed to determine the amount of formaldehyde associated with the particulate material on each filter. The PVC filters and cellulose back-up pads were analyzed using an experimental formaldehyde-on-dust method developed by the Division of Physical Sciences and Engineering, NIOSH[1], incorporating analysis by high pressure liquid chromatography (HPLC). The filters were desorbed with 10 mL of deionized water, placed in a 37 C bath for four hours, and then filtered through a 0.45 um filter to remove the particulate material. The solutions were then analyzed using the 2,4-dinitrophenylhydrazine (DNPH) method.[2] For the vapor phase formaldehyde determinations, the impinger solutions were analyzed using visible absorption spectrophotometry, in accordance with NIOSH Method 3500.[3]

Area air samples for formaldehyde and particulates were collected in the glue room, furnace room, and front office. The sampling train consisted of a pre-weighed PVC filter followed by two midget impingers containing 1% sodium bisulfite solutions. Air was sampled at a flowrate of 1 Lpm using calibrated air sampling pumps. The particulate and formaldehyde analyses (vapor phase and particulate-bound) were performed as described above.

Evaluation Criteria

As a guide to the evaluation of the hazards posed by work place exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other work place exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled to the level set by the evaluation criterion. These combined effects are not often considered by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the work place are: 1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) Permissible Exposure Limits (PELs). Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA PELs. The OSHA PELs may be

required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

Formaldehyde

Formaldehyde is a colorless gas with a strong, pungent odor detectable at low concentrations. It is commonly utilized as formalin, an aqueous solution containing 37-50% formaldehyde by weight.[4] It is widely used in the production of resins, in the manufacture of many other compounds, as a preservative, as a sterilizing agent, and as an embalming fluid.[5]

Exposure to formaldehyde can occur through inhalation or skin absorption.[6] The primary non-carcinogenic effects associated with formaldehyde exposure are irritation of the mucous membranes of the eyes and respiratory tract, and allergic sensitization of the skin. The first signs or symptoms noticed on exposure to formaldehyde, at concentrations ranging from 0.1 to 5 ppm, are burning of the eyes, tearing, and general irritation of the upper respiratory passages. There does, however, appear to be a great deal of variation among individuals, both in terms of their susceptibility and tolerance.

Dermatitis due to skin contact with formaldehyde solutions and formaldehyde-containing resins is a well-recognized problem. Both primary skin irritation and allergic dermatitis have been reported.[4] Dermatitis may appear a few days following the commencement of work or may not appear for a number of years following exposure.[6]

In two separate studies, formaldehyde has induced a rare form of nasal cancer in rodents following repeated inhalation exposure.[7,8] In April 1981, NIOSH issued Current Intelligence Bulletin 34, "Formaldehyde: - Evidence of Carcinogenicity", DHHS (NIOSH) Publication No. 81-111.[9] In this bulletin, NIOSH recommends that formaldehyde be handled as a potential occupational carcinogen and that appropriate controls be used to reduce worker exposure to the lowest feasible level.[4] This recommendation was based primarily on a study in which nasal cancers developed in rats and mice following repeated inhalation exposures of approximately 15 ppm formaldehyde. In December, 1987, OSHA published an amended formaldehyde standard, 29 CFR 1910.1048. This standard reduced the PEL from 3 ppm to 1 ppm, as an 8-hour TWA.[10] In

addition, a 15-minute short term exposure limit (STEL) was set at 2 ppm. ACGIH has given formaldehyde an A2 designation, indicating that ACGIH considers formaldehyde a suspected human carcinogen. The ACGIH TLV for formaldehyde is 1 ppm as an 8-hour TWA and 2 ppm as a 15-minute STEL.[11] ACGIH has recently proposed a ceiling limit of 0.3 ppm formaldehyde in their notice of intended changes for 1989-1990.[11] This value will be reconsidered for the adopted TLV list after 2 years.

Wood Dust

Airborne particle board dust generated during cutting and milling operations consists of particles of hard and soft wood. This wood dust is comprised of particles of various sizes and shapes which may be suspended in air and inhaled. Those particles inspired with an aerodynamic diameter greater than 20 microns (um) are deposited by impingement in the nose and oral region. Smaller particles, <20 um to 10 um can penetrate past the larynx and are deposited in the upper bronchial region, while particles from 10 um to <0.5 um are carried into the smaller airways and the alveoli of the lung.

Exposure to wood dust has been reported to have resulted in numerous health effects including allergic reactions[12], chronic non-allergenic respiratory disease[13], and nasal sinus cancer.[14] Obstructive respiratory effects[13], development of lung fibrosis[15], and impairment of the mucociliary clearance mechanism[16] also have been reported.

Formaldehyde and other gaseous compounds can be adsorbed on wood particles. Wood dust and formaldehyde are both recognized as causing respiratory irritation and sensitization.[12,13] It is possible that inhaled wood particles containing formaldehyde can release formaldehyde at the site of particle deposition. Recently, two epidemiologic studies have been reported which suggested an increase in cancers of the upper respiratory passages in garment and resin manufacturing workers in which the source of formaldehyde was assumed to be low level and vapor phase, however, the plants were noted to be dusty.[14,15] One hypothesis for these findings is that the nasopharyngeal and buccal cavity (throat region) areas may be receiving additional formaldehyde exposure from the deposition of formaldehyde containing particulate material in addition to the vapor phase formaldehyde which evolves from these materials. Much work remains to be done in this area, however, to better assess the effect of formaldehyde containing dust on the incidence of upper respiratory tract cancers. The analytical method developed by NIOSH researchers to measure low levels of formaldehyde that may be physically adsorbed or chemically bound on the particles is an important first step in this process.

The Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for soft and hard wood dust except western red cedar is 5 milligrams of dust per cubic meter of air (mg/m^3) and for western red cedar is 2.5 mg/m^3, both as 8-hour time-weighted averages (TWA). The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value

(TLV) for hard wood dust is 1 mg/m^3 and 5 mg/m^3 for soft wood dust as 8-hour TWAs.[11] NIOSH has not established a Recommended Exposure Limit (REL) for wood dust, however, in a white paper submitted to OSHA in 1987, NIOSH reported that the exposure data for wood dust--soft wood meets the OSHA definition of a potential occupational carcinogen, therefore, NIOSH recommends that OSHA label this substance as a potential occupational carcinogen. NIOSH also indicated that it does not agree that soft wood dust should be considered separately from hard wood dust and has suggested that 1 mg/m^3 should be used as an interim level to be followed by future rulemaking.[17]

Results and Discussion

Personal breathing zone (PBZ) and general area (GA) air sampling results for formaldehyde and particulate material are shown in Table 1. The concentration of total particulate material in PBZ air samples ranged from 0.8 mg/m^3 for a trothing operator whose exposure to wood dust is limited to cross contamination from the milling area, to 6.7 mg/m^3 for the cross cut saw operator who worked throughout the day mitering edges of particle board. This concentration exceeds the OSHA PEL and ACGIH TLV for wood dust of 5 mg/m^3. Using 1 mg/m^3 as the evaluation criteria, all three PBZ air samples collected on workers performing woodworking activities exceed this recommended level. Due to the concern regarding the potential for carcinogenicity, and the fact that particle board can contain soft and hard woods as well as western red cedar, it seems prudent that the most protective criteria be used for evaluation.

The concentrations of total particulate material in area air samples ranged from 0.6 mg/m^3 in the front office to 1.4 mg/m^3 in both the glue and furnace rooms. Although there is no cutting or other woodworking activities performed in the glue room there is the potential for cross contamination from the adjacent mill area. The furnace room contains a stove which is used to burn scraps of particle board (for supplemental heating) and which also houses some woodworking activities from another company which leases space within the warehouse. At the time of our visit, workers were cutting wedgewood in the back of the furnace room which created large amounts of dust. Reportedly, a new dust collector had recently been purchased for this unit, and was to be installed in the near future.

The vapor phase formaldehyde concentrations ranged from 0.06 parts per million (ppm) in the front office to 0.31 ppm in the glue room. Concentrations of 0.14 to 0.15 ppm were measured in the furnace room, as well as on PBZ air samples obtained on the two mill operators and the cross cut saw operator. The GA air concentration in the glue room is approximately twice as great as in adjacent areas, most likely as a result of the elevated air temperatures in this room due to the RF equipment. The formaldehyde concentrations were all below the OSHA PEL and ACGIH TLV of 1 ppm. NIOSH, however, recommends that exposures be reduced to the lowest feasible level, as formaldehyde is considered a potential carcinogen.

Of the seven particulate samples analyzed for formaldehyde content, the concentrations ranged from trace (between the analytical limit of detection (LOD) and limit of quantitation (LOQ)) to 36.9 micrograms of formaldehyde per cubic meter of air (ug/m^3). The data collected with this method should be interpreted cautiously, however, as this is an experimental method with no background data for comparison. The evaluation does indicate, however, that particle board dust generated during woodworking operations contains formaldehyde which may be bound or physically adsorbed on the particles, and although the concentrations of formaldehyde found are much lower than in the vapor phase, these low levels can be measured reliably by this method. In addition, the two types of measurements cannot be directly compared, as the particulate formaldehyde data may represent an exposure potential at the point of particle retention in the breathing passages, while the vapor phase formaldehyde data represents an exposure which would encompass the entire respiratory tract. There are presently no workplace evaluation criteria for formaldehyde-containing particulate material.

Summary

The industrial hygiene evaluation conducted in January 1990, indicates the need for improved local exhaust ventilation to reduce the levels of particulate materials generated during cutting and milling operations, especially for the cross cut saw which had obvious ventilation deficiencies (on the right side) and resulted in a total particulate exposure of 6.7 mg/m^3 for the operator. Improving the local exhaust ventilation should also reduce the formaldehyde burden associated with particles that could have deposited in the respiratory tract and may also help to lower vapor phase formaldehyde levels by reducing the amount of particulate material available to release formaldehyde to the air. Efforts to reduce formaldehyde and particulate levels should be made since formaldehyde and wood dust are considered by NIOSH as potential carcinogens. Reducing the levels of these substances should also reduce symptoms of nose irritation which have been experienced by some workers. Based on air sampling data and observations from this investigation, the following recommendations are offered:

1. Improve the local exhaust ventilation on the cross cut saw. Incorporating the hood directly onto the equipment may be a more efficient means of exhausting this side of the dual saw. In addition, a more permanent seal should be provided for the seam on this side which appears to be a major source of dust generation. The tape which is currently used does not provide an adequate seal.

2. To minimize the generation of dust when the bags are changed, consideration should be given to moving the particulate collection system outdoors if possible, or alternately to enclose and ventilate this area, as the current practice results in the generation of fine wood dust which is then dispersed throughout the work area.

3. To reduce formadehyde levels in the glue room, consideration should be given to increasing the dilution ventilation, by providing more outside air to this area.

4. Air hoses should not be used to clean clothing or equipment, as this practice generates large amounts of dust in the workers' breathing zone. Vacuuming should be performed whenever possible, to minimize reentrainment of wood dust.

5. Smoking should not be allowed in the work area for both health and safety reasons.

6. The use of goggles and ear protection should be enforced for saw operators.

7. If Superior Manufacturing continues burning particle board scraps for supplemental heating, consideration should be given to providing additional make-up air for this unit or providing a separate enclosed and ventilated area for the stove. On the afternoon of our survey the stove generated a lot of smoke which filled the warehouse area. Carbon monoxide (CO) levels measured using direct reading detector tubes indicated a concentration of 15 to 20 ppm in the work area. Although this concentration is below the NIOSH REL of 35 ppm as an 8-hr TWA, it is possible that the concentration of CO could vary considerably on any given day. Carbon monoxide is major product of incomplete combustion, and exposure can result in symptoms of headache, nausea, weakness and dizziness.

8. Periodic exposure monitoring for formaldehyde and wood dust should be conducted, particularly following any ventilation or work practice changes.

In accordance with the requirements of NIOSH regulations (29 CFR, Title 42, Part 85), for the purpose of informing affected employees of the results of our evaluation, this report must be posted for a period of at least 30 calendar days in an area readily accessible to the workplace(s) of affected employees.

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Table 1

Air Sampling Data for Formaldehyde and Total Particulate Material

Superior Manufacturing
Cincinnati, Ohio
January, 1990

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Job/ Location	Sampling Time (min)	Sample Volume (L)	Total Particulate Material (mg/m^3)	Particulate-Bound Formaldehyde (ug/m^3)	Formaldehyde Vapor (ug/m^3)	Formaldehyde Vapor (ppm)
Personal Air Samples:						
Mill Operator	425	425	1.5	(7.8)[a]	172	0.14
Mill Operator	418	418	3.7	21.5	172	0.14
Cross Cut Saw Operator	271[b]	271	6.7	36.9	179	0.15
Trothing Operator	417	417	0.8	(3.1)	105	0.09
Area Air Samples:						
Glue Room - on shelf behind conveyor	214[b]	203	1.4	(3.0)	375	0.31
Furnace Room - near Dri-Quick oven	425	425	1.4	21.2	180	0.15
Front Office - on wall to reception area	467	467	0.6	ND[c]	79	0.06
NIOSH Recommended Exposure Limit (REL)			[d]	NA	LFL[e]	LFL
OSHA Permissible Exposure Limit (PEL) (wood dust)			5, 2.5[f]	NA	1227	1
ACGIH Threshold Limit Value (TLV) (wood dust)			5, 1[g]	NA	1227	1

[a] Values in parentheses indicate concentrations which were between the limit of detection (LOD) and limit of quantitation (LOQ). The LOD for the particulate-bound formaldehyde analysis was 0.42 ug/sample and the LOQ was 4.2 ug/sample. For the vapor phase formaldehyde analysis, the LOD and LOQ were 2 ug/sample and 22 ug/sample, respectively.
[b] Indicates partial-shift air samples. Air samples collected in the afternoon were invalidated as a result of pump failures.
[c] ND = none detected.
[d] NIOSH does not currently have a REL for wood dust, however, NIOSH has suggested to OSHA that an interim level of 1 mg/m^3 be used for both hard and soft wood dust.[9]
[e] LFL = lowest feasible level.
[f] OSHA PELs for all wood dust except western red cedar and for western red cedar, respectively.
[g] ACGIH TLVs for softwoods and for certain hardwoods such as beech and oak, respectively.