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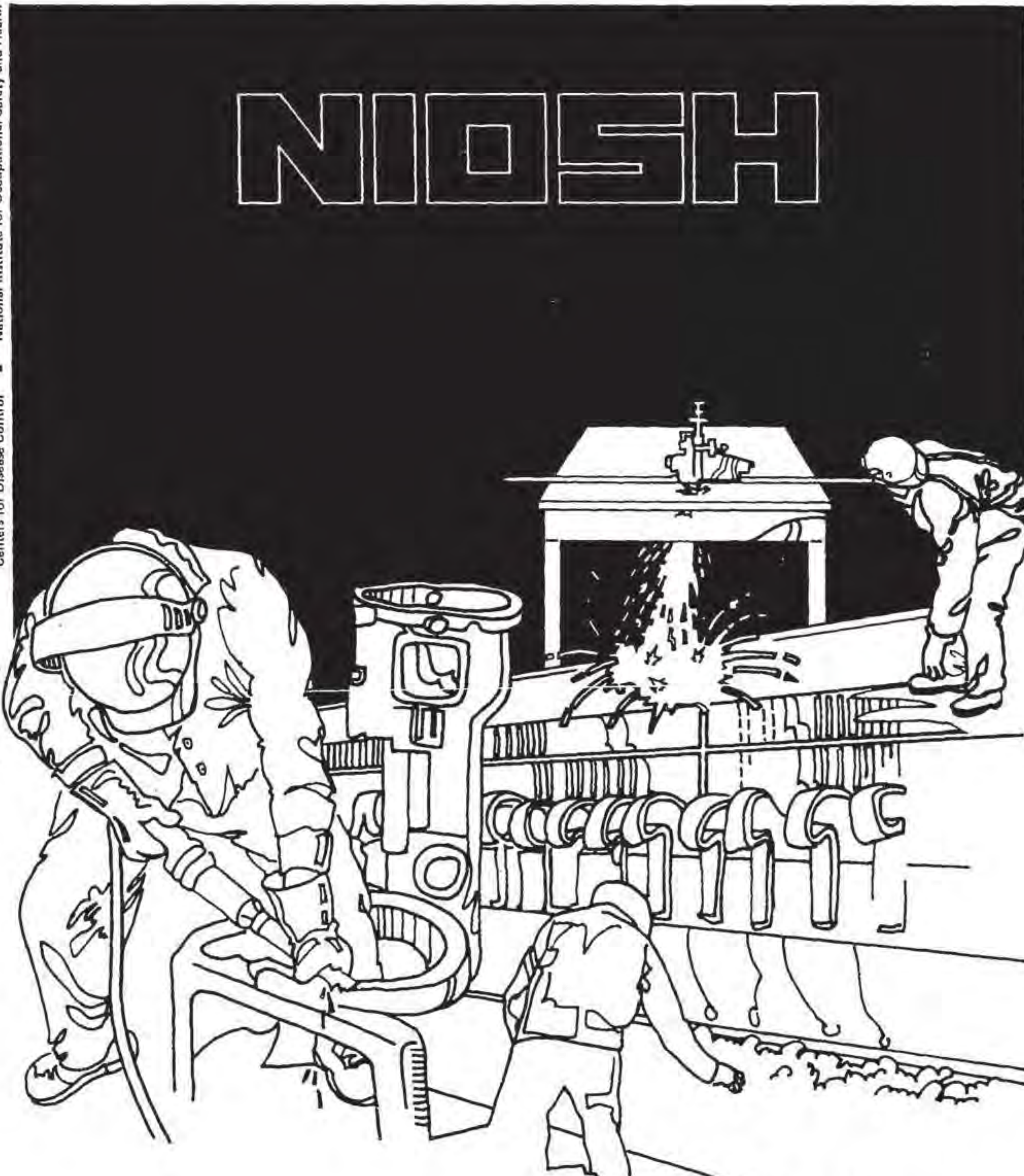

Health Hazard Evaluation Report

HETA 82-354-1897
KEMPER-TAPPAN
RICHMOND, INDIANA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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KEMPER-TAPPAN
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I. SUMMARY

On August 9, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation from an authorized representative of employees at the Kemper plant in Richmond, Indiana. This plant manufactures cabinets for household use. The request concerned recurring upper respiratory illness, possibly related to formaldehyde and solvent exposures in the production area of the plant. This report presents the results from the initial environmental and medical evaluation conducted at the Kemper plant on October 19-20, 1982, and results from the environmental evaluation on September 27-30, 1983 by NIOSH investigators.

Personal breathing zone air samples for formaldehyde, other organic hydrocarbons, alcohols, and nuisance dust were obtained for various jobs in six process areas where exposure potential to these compounds existed. Formaldehyde exposure levels ranged from non-detectable (ND) to 0.56 ppm. The primary assembly and finishing areas of this plant had the highest formaldehyde exposure levels ranging from 0.11 ppm to 0.22 ppm, and 0.10 to 0.56 ppm, respectively. NIOSH currently considers formaldehyde a human carcinogen and recommends that formaldehyde exposures be maintained at the lowest feasible level. Personal exposure to toluene ranged from ND to 16.4 ppm and xylene exposure ranged from ND to 22.1 ppm for the jobs sampled. Exposure to methyl ethyl ketone (MEK) and methyl isobutyl ketone (MIBK) was documented in 8 jobs and ranged from ND to 9.60 ppm and ND to 14.10 ppm, respectively. Exposure levels to butanol, isobutanol, and isopropanol were determined for 9 jobs; these levels ranged from ND to 0.27 ppm, ND to 0.16 ppm, and ND to 0.15 ppm, respectively. Exposure to respirable and total nuisance dust ranged from no-measurable-amount (NMA) to 0.44 mg/m^3, and NMA to 2.8 mg/M^3, respectively.

The personal exposure measurements for organic hydrocarbons, MEK, MIBK, and alcohols were all considerably below the applicable NIOSH, OSHA, and ACGIH exposure criteria. Exposure levels to nuisance dust in two job operations exceeded the ACGIH TLV for hardwood dust exposure. The OSHA standards for respirable and total nuisance dust were not exceeded.

An attempt was made to determine the formaldehyde content of the wood aerosol. The attempt was not successful due to limitations of the sampling methodology currently available. Therefore, neither the amount of formaldehyde adsorbed to, nor the amount bound in, the wood dust particles could be determined. In conjunction with this, the possible physiological insult from the combined exposure to wood dust and formaldehyde could not be evaluated.

Medical interviews of 46 workers at this plant identified symptoms compatible with formaldehyde and solvent exposure.

Based on these results, it has been determined that a potential health hazard from airborne exposures to formaldehyde and to hard wood dust existed among workers in the Kemper-Tappan plant. Formaldehyde exposure exceeded the NIOSH recommended exposure limit in 77% of the jobs sampled, and exceeded the current OSHA action level of 0.5 ppm in one job operation. Exposure to hard wood dust exceeded the ACGIH TLV of 1.0 mg/m^3 for two job operations. Recommendations to reduce exposures are provided in Section VIII of this report.

KEYWORDS: SIC 2434 (wood cabinet manufacture) formaldehyde, wood dust, respiratory effects, methyl ethyl ketone, methyl isobutyl ketone, toluene, xylene, alcohols

II. INTRODUCTION

On August 9, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation from an authorized representative of employees at the Kemper plant in Richmond, Indiana. The request concerned recurring upper respiratory illness, possibly related to formaldehyde and solvent exposures in the production area of the plant. This report presents the results from the initial environmental and medical evaluation conducted at the Kemper plant on October 19-20, 1982, and results from the environmental evaluation on September 27-30, 1983 by NIOSH investigators.

III. BACKGROUND

The Kemper plant in Richmond, Indiana (a division of the Tappan Company since 1968) manufactures wood and wood product cabinets for household use in a variety of styles and finishes. At the time of these evaluations, there were approximately 270 production employees operating on a single workshift. These production employees are represented by the United Steelworkers of America (Local 5163). A health and safety committee consisting of management and union representatives meets monthly to address health and safety issues at the plant.

The cabinet manufacturing process begins with cutting veneered particle board sheets and natural grain wood (from the raw material storage area) to the desired size for use as cabinet components. These components are then further worked in the millroom as necessary using power planers, groovers, notchers, sanders, and drills in preparation for primary assembly. In the primary assembly operation, the cabinet cases and their corresponding doors and drawer fronts are assembled separately using wood glue and industrial staplers. These sub-assemblies are then sent to the finishing department where there are two separate finishing lines; one for cabinet cases, the other for doors and drawer fronts. In the finishing operation, the exterior natural grain wood surfaces are sprayed in spray booths with a stain, a sealer, and a glossy top coat. Some of the doors and drawer fronts are sprayed with a stain which is then handwiped. The sub-assemblies are dried in gas-fired ovens after the application of each spray finish. The finished sub-assemblies are then moved to the final assembly department where the doors, drawers and accessory hardware are attached to the cabinet case. The completed cabinets are then boxed and sent to the warehouse for storage prior to shipment.

In 1983, approximately 60 percent of the cabinets produced used particle board with vinyl veneer, 30 percent used particle board with natural grain wood veneer, and 10 percent used filled particle board. Production trends indicated an increasing use of vinyl veneered particle board.

Local exhaust ventilation was utilized at the majority of powered woodworking machinery, spray booths, and drying ovens used in the production operations at the Kemper plant.

IV. EVALUATION DESIGN

Environmental

NIOSH personnel conducted an initial environmental and medical investigation at the Kemper plant on October 19 and 20, 1982. During this initial investigation, detailed information concerning the production operations was obtained, direct-reading measurements for formaldehyde and organic hydrocarbon vapors were collected, cursory ventilation measurements were obtained, and existing conditions and work practices were observed. Also, direct-reading formaldehyde measurements were collected at the major process operations throughout the plant using a calibrated CEA Instruments Model 555 air monitor and strip chart recorder. The direct-reading organic hydrocarbon vapor measurements were collected at solvent operations using an Hnu Model PI 101 photoionization analyzer. Ventilation measurements were obtained at several process operations using a Kurz Model 440 air velocity meter and smoke tubes.

An assessment of employee exposure to formaldehyde, solvents, and nuisance dust was conducted on September 27-30, 1983 in areas throughout the plant where exposure potential to these compounds existed. Full shift personal breathing zone samples for formaldehyde were collected using NIOSH Method 2501.[1] These samples were collected on 150 mg Supelco Orbo 22 tubes using SKC Model 222-3 low-flow pumps calibrated at a flow rate of 50 ml/minutes. The samples were analyzed using gas chromatography equipped with flame ionization detector (GC-FID). The analytical limit of detection (LOD) for this set of analyses was 1.0 ug/sample.

General area (GA) formaldehyde sampling was conducted according to NIOSH Method 3500.[1] Samples were collected in midget impingers containing 20 ml of a 1% sodium bisulfite solution using duPont Model 2500A pumps calibrated at 1.0 liters per minute (LPM). Samples were analyzed using visible absorption spectrophotometry. LOD for this set of analyses was 0.1 ug/milliliter of sample.

Personal breathing zone full shift and GA sampling for toluene and xylene was conducted according to NIOSH Method 1501.[1] These samples were collected on 150 mg SKC charcoal tubes using SKC Model 222-3 low flow pumps calibrated at a flow rate of 50 ml/minute. The samples were analyzed by GC-FID at an LOD of 0.01 mg per sample.

Personal breathing zone full shift exposure sampling for methyl ethyl ketone (MEK) and methyl isobutyl ketone (MIBK) was performed using NIOSH Method 2500.[1] These samples were collected using 240mg SKC Ambersorb XE 347 tubes and SKC Model 222-3 low flow pumps calibrated at a flow rate of 50 ml/minute. Sample analysis was performed by GC-FID with an LOD of 0.03 mg/sample.

Personal full shift exposure sampling for alcohols (butanol, isobutanol, and isopropanol) was conducted according to NIOSH Method 1400.[1] Samples were collected on 150 mg SKC charcoal tubes using SKC Model 222-3 low-flow pumps calibrated at a flow rate of 50 ml/minute. Analysis of these samples was conducted by GC-FID with an LOD of 0.01 mg/sample.

Personal exposure to nuisance dust, total and respirable fraction, was conducted using pre-weighed 37 mm 5.0 um pore-size poly vinyl chloride (PVC) filters. Model P2500A duPont pumps calibrated at 2.0 LPM were used to collect total dust samples. These same model pumps in conjunction with 10 mm nylon cyclone preseparators, calibrated at a flow rate of 1.7 lpm, were used to collect respirable dust samples. Filter samples were analyzed gravimetrically.

The size distribution of the nuisance dust was characterized by gravimetric aerodynamic sizing methodology using a 9-stage Andersen Ambient Sampler with a preseparator.[2] Each stage contained a pre-weighed 81 mm 5.0 um pore-size PVC filter. Gast rotary vane pumps calibrated at a flow rate of 1 cubic foot per minute (cfm) were used to collect approximately 8-hour samples. Each filter was analyzed gravimetrically to yield a dust concentration for each size fraction.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ evaluation criteria for 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 workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in 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 workplace are: 1) NIOSH Criteria Documents and Recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[3] and 3) the U.S. Department of Labor (OSHA) occupational health standards[4]. Often, the NIOSH recommendations and ACGIH TLVs usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, 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 standard.

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 (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. Toxic Effects of Formaldehyde

Formaldehyde gas is an irritant of the eyes and the respiratory tract; solutions cause both primary irritation and sensitization dermatitis.[5] The first signs or symptoms noticed upon exposure to formaldehyde, at concentrations ranging from 0.1 to 0.5 ppm, are burning of the eyes, tearing, and general irritation of the upper respiratory passages. Higher exposures (5 to 20 ppm) may produce coughing, tightening of the chest, a sense of pressure in the head, and palpitation (noticeable beats) of the heart. In 1976 NIOSH developed a REL for formaldehyde of 1 ppm to prevent the irritant effects of exposures to this compound.[6] This recommendation predated animal carcinogenicity data implicating formaldehyde as a animal carcinogen and a potential occupational carcinogen. Formaldehyde has also produced positive results in mutagenicity testing, supporting the classification of this compound as a potential occupational carcinogen. NIOSH currently considers formaldehyde a human carcinogen and recommends that formaldehyde exposures be maintained at the lowest feasible level.[7,8]

On December 4, 1987, OSHA promulgated a new health standard for formaldehyde, which became effective on February 2, 1988.[9] In this revised standard, OSHA considers formaldehyde a probable human carcinogen. The PEL was reduced by two thirds, from 3 ppm to 1 ppm, as an 8-hour TWA, with an "action level" of 0.5 ppm. Exposures up to 2 ppm would be permitted for 15-minute periods, as long as the daily exposure does not exceed 1 ppm. The revised standard contains provisions for medical surveillance, recordkeeping, regulated areas, emergency procedures, control strategies, protective equipment, and hazard communication.

The ACGIH TLV for formaldehyde is 1 ppm, as an 8-hour TWA, but also classifies formaldehyde as a suspected human carcinogen necessitating that exposures be kept to a minimum.[3]

C. Toxic Effects of Organic Hydrocarbons

The evaluation criteria, including known health effects, for the individual organic hydrocarbon components of commercial compounds currently used in the finishing and assembly departments at the Kemper plant are presented in Table 1.

D. Toxic Effects of Wood Dust

Airborne dust in the cabinet manufacturing industry consists of particles of hard and soft wood created by powered wood working tools. This wood (nuisance) dust is comprised of particles of various sizes and shapes which may be suspended in air and inhaled. Those particles inspired with an aerodynamic equivalent 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. Particles from 10 um to <0.5 um are carried into the smaller airways and the alveoli of the lung. This latter range of particle diameters is considered the respirable portion and may represent an increased potential for a health hazard.

Formaldehyde and other gaseous compounds can be adsorbed on wood particles; or formaldehyde may be a natural constituent of wood aerosols generated from formaldehyde resin treated particle board. Wood dust and formaldehyde are both recognized as causing respiratory irritation and sensitization.[5,10] It is possible that inhaled wood particles containing formaldehyde (or other gaseous compounds) can release formaldehyde at the site of particle deposition.

Exposure to wood dust has been reported to have resulted in numerous health effects including allergic reactions[11], chronic non-allergic respiratory disease[12], and nasal sinus cancer.[13] Obstructive respiratory effects[12], development of lung fibrosis[14], and impairment of the mucociliary clearance mechanism[15] also have been reported. The OSHA standard for respirable nuisance dust is 5 mg/m^3 and for total dust is 15 mg/m^3.[4] The ACGIH TLV for hard wood nuisance dust is 1 mg/m^3 and 5 mg/m^3 for soft wood nuisance dust with a STEL of 10 mg/m^3.[3,16]

VI. RESULTS AND DISCUSSION

A. Environmental

At the Kemper plant, the primary source of formaldehyde is from the particle board used in the manufacture of cabinets since formaldehyde-derived synthetic resins are used as adhesives in the production of particle board. Formaldehyde is released continuously from the finished particle board sheets. This rate of offgassing decreases over time and is affected by several factors including temperature and relative humidity.[10] Additionally, common woodworking techniques such as sawing, planing, grooving, notching, sanding, and drilling may increase the amount of formaldehyde offgassing by providing new exposed surfaces.

Formaldehyde is also used in very small amounts as a constituent of two wood glues used at the Kemper plant. These small amounts, however, should not add significantly to the airborne concentration of formaldehyde.

Table 2 summarizes general area formaldehyde concentrations as determined on October 20, 1982. These GA airborne formaldehyde concentrations, measured with the CEA 555 air monitor, ranged from 0.07 ppm in the particle board storage area to greater than 2.14 ppm at the drying oven exit in case finishing. Except for the case finishing drying oven exit, all measured formaldehyde concentrations were less than 0.4 ppm. Since these measurements were general area, short duration samples, they do not accurately reflect the actual TWA exposures of the employees, and therefore, cannot be used for comparison with the formaldehyde evaluation criteria previously discussed in Section IV of this report.

The personal 8-hour TWA formaldehyde exposure levels as determined during the September, 1983 survey are presented in Table 3. These exposure levels are listed by job title within a plant process area. TWA exposure levels ranged from non-detectable to 0.56 ppm. The majority of these formaldehyde exposure levels (77%) are above the NIOSH REL and one (0.56 ppm for the end of Line Inspector, Finishing Department) is above the current OSHA action level of 0.5 ppm as previously discussed in Section IV. By department area, the primary assembly and finishing areas had the highest exposure levels ranging from 0.11 ppm to 0.22 ppm (mean=0.15, N=4) and 0.10 to 0.56 ppm (mean=0.25, N=5) respectively. These levels are similar to the mean GA concentrations (See Table 2) found with the CEA Air Monitor on October 20, 1982 at the Primary Assembly area (0.12 ppm mean concentration), the door finishing area (0.25 ppm mean concentration), and the case finishing area (>0.63 ppm concentration).

GA air monitoring for formaldehyde was also conducted during the September, 1983 survey and these concentrations are reported in Table 4. During the 1983 survey, the GA formaldehyde concentrations ranged from 0.05 ppm at the Giben Saw #2 to 0.25 ppm at the Giben Saw #1 and also at the case finishing area.

Exposure to organic hydrocarbons at the Kemper plant occur primarily to employees using solvents, spray finishes (including touch-up finishes), and to a much lesser extent, glues and adhesives. The vast majority of commercial compounds used in this capacity are actually mixtures containing several individual organic hydrocarbon components. A listing of the organic hydrocarbon components of these commercial compounds, obtained from information supplied by the individual manufacturers, is presented in Table 1.

Total airborne organic hydrocarbon concentrations measured during the 1982 survey with the Hnu photoionization analyzer ranged from 1 to 300 ppm. Highest concentrations (greater than 100 ppm) were obtained in the Omega door assembly, case finishing, and touch-up finishing operations. The total organic hydrocarbon results are summarized in Table 3. As with the formaldehyde measurements, the organic hydrocarbon measurements were general area, short duration samples and do not accurately reflect the actual TWA exposures of the employees. In addition, these measurements were of total organic hydrocarbons and cannot be used for comparison with the evaluation criteria of the individual organic hydrocarbon constituents listed in Table 1.

Personal 8-hour TWA exposure levels for toluene, xylene, MEK, MIBK, butanol, isobutanol, and isopropanol obtained during the September, 1983 survey are presented in Table 6. Toluene exposures ranged from non-detectable to 16.4 ppm in the jobs sampled. The case finishing area had the highest toluene exposure levels. Exposure to xylene ranged from non-detectable to 22.1 ppm, with the case finishing and door finishing areas representing the highest xylene exposure levels. Exposure to MEK was detected for only 2 of 8 jobs sampled; 2.45 ppm for a door finisher and 9.60 ppm for a case finisher. MIBK exposure occurred in 4 of 8 jobs sampled and these levels ranged from 1.90 ppm to 14.10 ppm for case finishers. Exposure levels to alcohols are reported for 9 jobs and range from non-detectable to 0.27 ppm for butanol, 0.16 ppm for isobutanol, and 0.15 ppm for isopropanol.

GA air concentrations of toluene and xylene are presented in Table 4. GA air concentrations of toluene ranged from non-detectable to 1.30 ppm. Xylene concentrations ranged from non-detectable to 0.78 ppm. The case-finishing area represented the highest GA concentrations of toluene and xylene.

None of the exposure levels for toluene, xylene, MEK, MIBK, or alcohols reported in Tables 4 or 6 exceeded any of the respective evaluation criteria as presented in Table 1.

Personal exposure levels to nuisance dust, total and respirable portion, are presented in Table 7. Total dust exposure levels as determined for ten jobs ranged from no measurable amount (NMA) for the pickle operator and during installation of door hinges to 2.8 mg/m^3 for the bandsaw operator. The respirable portion of nuisance dust exposure was characterized for 17 jobs. Respirable dust exposure ranged from NMA during drilling of door frames and for the pickle operator to 0.44 mg/m^3 for a sander operator. Jobs which utilized saws, sander, or shaping tools appeared to create the highest total and respirable dust exposures. Total dust exposures for a bandsaw operator and a shaper operator exceeded the ACGIH TLV of 1.0 mg/m^3 for hard wood dust exposure.

The concentrations of wood dust, categorized by size, for three areas in the plant are depicted in Table 8. The size distributions presented in this table indicate that 52 to 70% of the total dust concentration for a given area has an aerodynamic size less than 9 um. Thus a considerable portion of this wood dust is of a size which can penetrate past the larynx. The last column of this table represents the dust concentration in the approximate size ranges of easily respirable and suspendable particles; those which can penetrate to the gas exchange region of the lung.

An attempt to determine the amount of adsorbed formaldehyde on total and respirable portions of the wood aerosol was made during the 1983 survey. The results of this sampling effort will not be reported due to several problems encountered in the interpretation of the data. Specifically, the data is not meaningful without further research and understanding of the dynamics of formaldehyde release from particulates. The state of formaldehyde in these particulates may either be physically-adsorbed onto the surface and/or chemically bound in the particulate. The sampling methodology used to collect the data during this survey was not suitable to distinguish or differentiate these two aspects of formaldehyde constituency.

The cursory ventilation measurements made during the October, 1982 survey at several of the powered woodworking machines and spray booths indicated that the local exhaust systems were operating. These measurements were not, however, detailed enough to permit a determination concerning effectiveness of their operation.

A more comprehensive evaluation of the spray booths' effectiveness in reducing employee exposure to paint spray and solvents was performed during the September, 1983 survey. Specifically, booth numbers 1, 2, 3, 4a, 4b, 5, 6, and 7 of the case finish area and numbers 8, 9, 10, 11, and 13 of the door finish area were evaluated. Inlet velocity measurements of the exhaust ventilation on these paint booths were made using a Kurz model 440 air velocity meter. The face of each booth was divided into approximate 2 foot squares and the air velocity measured at the mid-point of each square across the full face of the booth. These air flow measurements indicated that 12 of the 13 spray booths evaluated were operating effectively according to ACGIH Industrial Ventilation Guidelines of 100-150 cubic feet per minute (CFM) per square foot of open area.[17]

Spray booth number 11 in the door finish area was found to operate at 50 cfm/ft^2 of open area. The extreme left ends of booth numbers 5, 6, 7, 10, and 13 were found to have air velocities ranging from 50-100 cfm. However, the air velocities at the working positions in these booths were 150 cfm or greater. This decreased air velocity at the left side of the booths may be the result of a design flaw.

Several observations of work practices which can defeat the effectiveness of the spray booths were made during this evaluation. Open cans of solvent (thinner) were observed sitting behind the spray operator allowing vapors to travel past the operator into the booth. One spray operator was required to use an open can of thinner to pump spray from; a closed system is preferred to minimize exposure. Spray operators were observed spraying in the opposite direction of the booth's opening thereby defeating the booths ability to capture exhaust the spray. Spray booths where two operators were working required a concerted effort by both to avoid direct spray from the other operators' gun.

VII. CONCLUSIONS

Formaldehyde exposure levels were shown to exceed the NIOSH REL and, in one case, the current OSHA action level during the 1983 survey. The personal TWA exposure levels, the general area concentrations, and the short-duration formaldehyde measurements indicate concentrations on the order of 0.4 ppm or less throughout the Kemper plant. The full shift TWA exposures are of the level at which a small percentage of employees would experience some irritation and discomfort while at work.

It has been reported in the scientific literature that formaldehyde adsorbed onto wood dust can contribute significantly to total formaldehyde exposures in cabinet manufacturing.[10-15] This aspect was not adequately evaluated in the initial sampling. To accurately assess the workers' exposure to formaldehyde for correlation with reported health effects, personal sampling which takes into account adsorbed formaldehyde as well as the gas phase from the wood aerosol needs to be performed. This sampling data may yield information which can be related to the recurring upper respiratory illness reported by employees at this plant.

The personal exposure measurements for organic hydrocarbons, MEK, MIBK, and alcohols were all considerably below the respective NIOSH, OSHA, and ACGIH exposure criteria.

Exposure levels to nuisance dust in two job operations exceeded the ACGIH TLV for hard wood dust exposure. The OSHA standards for respirable and total nuisance dust were not exceeded during this survey.

VIII. RECOMMENDATIONS

The following recommendations are based on good industrial hygiene practice and should reduce the potential for exposure.

1. Particle board suppliers should be consulted to assure that particle board used for cabinet construction contains modified urea-formaldehyde resin binders which limits the amount of free-formaldehyde emitted from the board. This will aid in reducing the formaldehyde emitted into the work room environment and in turn reduce exposure potential.

2. Each spray booth should be periodically evaluated to determine whether the system is functioning in accordance with design specifications. Flexible duct work should be kept to a minimum and, where necessary for use, be properly maintained. Several flexible dusts were observed to have holes or kinks in them.

3. Spray booth operators should be trained in the proper and effective use of the exhaust ventilation booth. This would include proper direction of spray, limiting the amount of work placed in the booth, and minimizing over-spray. All spraying should be accomplished using a closed system design. The practice of pumping from open containers should be avoided.

4. Gloves should be used to protect workers from dermal exposure to toluene on the omega door assembly. Substitution of a less toxic solvent for toluene should be investigated.

5. Compressed air hoses should not be used to clean dust from clothing.

6. Asbestos pipe insulation was noted to be damaged in several areas. The insulation at these points should be wrapped to prevent asbestos contamination of the work environment.

7. Several blast gates were missing in the ventilation duct work. These should be replaced and the exhaust systems evaluated for effectiveness to determine proper position of blast gate. Maintenance of local exhaust ventilation systems (e.g. hand held power tools) should be improved. Many local exhaust system hoods were poorly positioned to capture the dust created by the procedure. Placement and orientation of hoods should be evaluated.

IX. REFERENCES

1. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods, Volumes 1 and 2. 3rd ed. Cincinnati, Ohio 1984, DHHS (NIOSH) Publication No. 84-100.

2. Andersen Samplers Inc. operating manual for andersen sampler, 1 ACFM ambient particle sizing samplers. Atlanta, Georgia. Jan., 1979, TR#76-900016.

3. American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values and biological exposure indices for 1986-87. Cincinnati, Ohio: ACGIH, 1986.

4. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1983.

5. National Research Council. Formaldehyde and other aldehydes. Washington, D.C.: Committee on Aldehydes, National Research Council, 1981. (National Academy Press).

6. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to formaldehyde. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-126).

7. National Institute for Occupational Safety and Health. Testimony of the National Institute for Occupational Safety and Health on the Occupational Safety and Health Administration proposed rule: occupational exposure to formaldehyde 29 CFR 1910 docket no. H-225A. Atlanta, Georgia: National Institute for Occupational Safety and Health, 1986.

8. National Institute for Occupational Safety and Health. Current intelligence bulletin 34 -- formaldehyde: evidence of carcinogenicity. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1980. (DHHS publication no. (NIOSH) 81-111).

9. Department of Labor, Occupational Exposure to Formaldehyde, Final Rule, Federal Register, Volume 52, No. 253, December 4, 1987, pgs, 46168-46312.

10. Geissert JO. Formaldehyde air contamination and other health safety problems in a cabinet shop: a case study. Presented at the American Industrial Hygiene Conference, Chicago, Illinois, 1979.

11. Chan-Yeung M., GM Barton, L. MacLean and S. Grzybowski. Occupational asthma and rhinitis due to western red cedar. American Review of Respiratory Disease, 108:1094-1102 (1973).

12. Whitehead LW, T. Ashikaga and P. Vacek. Pulmonary function status of workers exposed to hard wood or pine dust. American Industrial Hygiene Association Journal. 42:178-186(1981).

13. Hills JH. Nasal carcinoma in woodworkers: A Review. Journal of Occupational Medicine Vol. 24, pages 526-529, (1982).

14. Michaels L. Lung changes in woodworkers. Canadian Medical Association Journal. 96:1150-1155 (1967).

15. Black A, Evans JC, Hadfield HE, MacBeth RG, Morgan A, and M Walsh. Impairment of nasal mucociliary clearance in woodworkers in the furniture industry. British Journal of Industrial Medicine. Vol. 31, pages 10-17, (1974).

16. American Conference of Governmental Industrial Hygienists: Documentation of the threshold limit values, Fifth Edition. ACGIH, Cincinnati, Ohio. pages 635-636, (1986).

17. American Conference of Governmental Industrial Hygienists Industrial Ventilation: A manual of recommended practice. 15th Edition. ACGIH. Cincinnati, Ohio. pages 5-73, (1978).

18. National Institute for Occupational Safety and Health. NIOSH/OSHA occupational health guidelines for chemical hazards. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1981. (DHHS (NIOSH) publication no. 81-123).

19. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to isopropyl alcohol. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-142).

20. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to methyl alcohol. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-148).

21. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to toluene. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1973. (DHEW publication no. (NIOSH) 73-11023).

22. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to xylene. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1975. (DHEW publication no. (NIOSH) 75-168).

23. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to vinyl acetate. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1978. (DHEW publication no. (NIOSH) 78-205).

24. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to methylene chloride. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-138).

25. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to 1,1,1-trichloroethane (methyl chloroform). Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-184).

26. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to ketones. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1978. (DHEW publication no. (NIOSH) 78-173).

27. National Institute for Occupational Safety and Health. Criteria for a recommended standard: occupational exposure to refined petroleum solvents. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-192).

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1. Kemper-Tappan
2. United Steelworkers of America, Local 5163
3. OSHA, Region 5

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Table 1

Evaluation Criteria* for Organic Hydrocarbon Components of Commercial Compounds Used in the Finishing and Assembly Departments

Kemper-Tappan
Richmond, Indiana
HETA 82-354

Chemical Classification	Organic Hydrocarbon	NIOSH Recommended Criteria	ACGIH TLV [3]	OSHA [4]	Health Effects[18]
Alcohols	n-butanol	-	50 ppm (c)	100 ppm	irritation of eyes, nose and throat; headache; drowsiness; dizziness; visual disturbances; nausea; dermatitis
	isobutanol	-	50 ppm	100 ppm	
	isopropanol	400 ppm (10 hr. TWA)[19]	400 ppm	400 ppm	
	methanol	200 ppm (10 hr. TWA)[20]	200 ppm	200 ppm	
Aldehydes	formaldehyde	(LFL)[6]	1 ppm (c)	1 ppm	irritation of eyes, nose and throat; cough; bronchial spasms; pulmonary irritation; nausea; dermatitis
Aromatic Hydrocarbons	phenyl acid phosphate	-	-	-	irritation of eyes, nose and throat; dizziness; headache; weakness; nausea; dermatitis
	toluene	100 ppm[21]	100 ppm	200 ppm	
	toluene sulfonic acid	-	-	-	
	xylene	100 ppm (10 hr. TWA)[22]	100 ppm	100 ppm	
Esters	vinyl acetate	4 ppm (c)[23]	10 ppm	-	irritation of eyes, nose, and throat; pulmonary irritation; visual disturbances; dermatitis
Glycol Ethers	butyl cellosolve	50 ppm	25 ppm	50 ppm	irritation of eyes, nose and throat; hemoglobinuria
Halogenated Alaphatic Hydrocarbons	methylene chloride	75 ppm (10 hr. TWA)[24]	100 ppm	500 ppm	irritation of eyes; headache; CNS depression; dermatitis
	1,1,1-trichloroethane	350 ppm (c)[25]	350 ppm	350 ppm	
Ketones	acetone	250 ppm (10 hr. TWA)[26]	750 ppm	1000 ppm	irritation of eyes, nose and throat; headache; narcosis; dizziness; dermatitis
	diacetone alcohol	50 ppm (10 hr. TWA)[26]	50 ppm	50 ppm	
	methyl (n-amyl) ketone	100 ppm (10 hr. TWA)[26]	50 ppm	100 ppm	
	methyl ethyl ketone	200 ppm (10 hr. TWA)[26]	200 ppm	200 ppm	
	methyl isobutyl ketone	50 ppm (10 hr. TWA)[26]	50 ppm	100 ppm	
Refined Petroleum Solvents	mineral spirits	350 mg/m^3 (10 hr. TWA)[27]	525 mg/m^3	2950 mg/m^3	irritation of eyes, nose and throat; headache; dizziness; dermatitis
	petroleum ether	350 mg/m^3 (10 hr. TWA)[27]	-	200 mg/m^3	
	VM&P naphtha	350 mg/m^3 (10 hr. TWA)[27]	1350 mg/m^3	-	

* Evaluation criteria listed are for 8-hour TWA exposures except where otherwise noted
(c) Ceiling concentration value that should not be exceeded (normally determined over a 15-minute sampling period)
(LFL) Lowest feasible level

Table 2

Formaldehyde Concentrations Measured with the CEA Air Monitor

Kemper-Tappan
Richmond, Indiana
HETA 82-354

October 20, 1982

Sample Location	Formaldehyde Range	Concentration (ppm) Mean
Particle Board Storage	0.07 to 0.16	0.10
Giben Saw #1	0.15 to 0.23	0.17
Giben Saw #2	0.18 to 0.20	0.19
Tenoner #1	0.18 to 0.21	0.19
Tenoner #3	0.21 to 0.27	0.25
Veneer Sander	0.28 to 0.34	0.31
Time Saver Sander	0.36 to 0.38	0.37
Omega Door Assembly	0.34 to 0.39	0.37
Primary Assembly	0.08 to 0.14	0.12
Exit to Drying Oven (door finishing)	0.16 to 0.34	0.25
Exit to Drying Oven (case finishing)	0.13 to >2.14	>0.63

Table 3

Personal Formaldehyde Exposure Levels

Kemper-Tappan
Richmond, Indiana
HETA 82-354

September 27-30, 1983

Date	Area/Job	Sample Time (min.)	Sample Volume (Liters)	Formaldehyde 8-hour TWA exposure (ppm)
9-27	Millroom/			
	Tenoner Oper.	442	22.3	0.11
	Drill Post Oper.	439	19.2	0.11
	Glue-Staple Fronts	429	20.7	0.15
	Frame Assembly	428	20.5	0.11
	Frame Assembly	420	18.7	0.13
	Tenoner Oper.	458	20.5	0.07
	Giben Saw Oper	450	22.7	0.07
	Giben Saw Helper	447	19.1	0.07
	Band Saw Oper.	443	22.0	0.06
	Sander (Walnut)	457	20.3	0.09
	Wall End Panel Oper.	445	21.9	0.03
	Base End Panel Oper.	440	19.8	0.07
	Giben Saw Oper.	453	22.2	0.07
	Tenoner Oper.	463	22.9	0.04
	Tenoner Oper.	455	22.8	0.07
	Sander (Walnut)	458	23.9	0.07
	Sander - Planer	455	25.5	0.11
	Tenoner Oper.	449	21.8	0.05
	Tenoner Oper.	450	18.4	0.04
	Door Driller	446	22.8	ND*
	Door Driller	443	20.0	ND
	Tenoner Oper.	440	22.7	0.05
9-28	Millroom/			
	Door Builder	450	25.8	0.09
	Door Builder	449	21.8	0.04
	Tenoner Oper.	446	19.9	0.07
	Utility Man	452	24.3	0.06
	Tenoner Oper.	440	22.2	0.10
	Giben Saw Oper.	452	21.4	Trace**
	Band Saw Oper.	300	17.9	ND
	Band Saw Oper.	372	17.9	0.05

Table 3 (continued)

Date	Area/Job	Sample Time (min.)	Sample Volume (Liters)	Formaldehyde 8-hour TWA exposure (ppm)
9-28	Primary Assembly/			
	Door Builder	475	23.1	0.04
	Door Stacker	474	22.8	0.04
	Door Stacker	472	24.4	0.04
	Door Builder	471	18.9	ND
	Door Builder	470	26.2	Trace
	Band-Variety Saw Oper.	453	21.8	ND
	Frame Building	180	13.6	ND
	Frame Building	465	17.9	0.07
	Salvage Room/			
	Molder Oper.	447	19.8	ND
	Salvage Oper.	449	21.2	ND
9-29	Primary Assembly/			
	Shell Assembly	475	23.3	0.22
	Shell Assembly	469	22.3	0.16
	Picker Operator	429	16.6	0.11
	Picker Operator	430	17.3	0.11
	Finishing/			
	End of Line Inspect.	444	19.5	0.56
	Sander after Sealer	437	19.6	0.16
	Sander after Sealer	437	21.9	0.31
	Case Finish, Sander	413	19.7	0.13
	Case Finish, Inspect.	412	17.8	0.10
	Final Assembly/			
	Touch-up Glueing	453	29.9	0.07
	Drawer Builder	454	18.9	0.05
	Drawer Builder	452	19.6	0.05
	Case Finishing-Area	472	20.4	0.10
9-30	Finishing/			
	Door Finish, Inspect.	442	20.5	ND
	Topcoat Sprayer	436	22.7	Trace
	Case Finish, Inspect.	425	18.9	ND
	Printer Oper.	426	22.4	ND

*ND = No Detectable Levels
**Trace = A Detectable Level too low to be fully quantified.

These samples were collected and analyzed according to NIOSH Method 2502.
The Limit of Detection (LOD) for this particular set of analyses was 1.0 ug/sample.

Table 4

General Area Air Monitoring

Kemper-Tappan
Richmond, Indiana
HETA 82-354

September 27-30, 1983

Date	Area (Wood Type)	Formaldehyde (ppm)	Nuisance Dust Total	Nuisance Dust Respirable	Aromatic Hydrocarbons Toluene	Aromatic Hydrocarbons Xylene
			(mg/m^3)		(ppm)	
9-27	Giben Saw #1 (Particle Bd)	0.06	0.17	0.20	0.18	ND*
	Giben Saw #2 (Particle Bd)	0.05	0.34	0.07	ND	ND
	Tennon #4 (Oak)	0.08	0.46	Trace*	ND	ND
	Tennon #3 (Oak)	0.16	0.75	0.13	0.21	ND
	Between Tennon #4 & Band Saw (Particle Bd - Oak)	0.08	0.40	Trace	0.18	ND
	Between Band Saw and Tennon #1 (Oak)	0.09	1.06	NMA**	0.20	ND
9-28	Giben Saw #1 (Particle Bd)	0.25	0.40	0.10	0.38	ND
	Giben Saw #2 (Particle Bd)	0.07	0.72	0.09	0.29	ND
	Tennon #4 (Particle Bd)	0.12	0.44	0.11	0.37	ND
	Tennon #3 (Particle Bd)	0.07	2.02	Trace	0.28	ND
	Between Tennon #4 and Band Saw (Particle Bd-Oak)	0.13	0.45	0.10	0.74	ND

Table 4 (continued)

Date	Area (Wood Type)	Formaldehyde (ppm)	Nuisance Dust Total (mg/m³)	Nuisance Dust Respirable (mg/m³)	Aromatic Hydrocarbons Toluene (ppm)	Aromatic Hydrocarbons Xylene (ppm)
9-28	Between Tennon #1 and Band Saw (Oak)	0.06	0.15	Trace	0.54	ND
	Between Solem Sander and Table Router	0.10	0.29	0.08	0.36	ND
	Door Building Area	0.08	0.29	0.09	0.36	0.18
9-29	Beginning of Case Line	0.24	0.35	Trace	0.47	0.18
	End of Case Line	0.20	0.30	NMA	0.26	0.18
	Center of 2BL Cabinet Line	0.14	0.10	Trace	0.05	0.08
	Raw Materials Storage Area	0.17	0.08	NMA	ND	ND
	Door Finishing-End of Dryer	0.22	0.17	Trace	0.37	0.11
	Case Finish-Entry to Dryer	0.18	Trace	NMA	1.15	0.72
9-30	Start of Case Line	0.20	0.28	NMA	0.47	0.18
	End of Case Line	0.18	0.18	Trace	0.37	0.19
	Center of Cabinet Line	0.13	0.13	Trace	0.42	0.08
	Door Finishing-End of Dryer	0.22	-	Trace	0.29	0.69
	Case Finishing-Entry	0.25	0.10	Trace	1.30	0.78
	Finished Goods Warehouse	0.15	0.10	Trace	0.15	ND

*ND = No Detectable Level
**NMA = No Measureable Amount
#Trace = A detectable level too low to be fully quantified.

Formaldehyde sampling and analysis was conducted according to NIOSH Method 3500. The Limit of Detection (LOD) for this set of analyses was 0.1 ug/milliliter of sample. Nuisance dust sampling was conducted using preweighed 37mm 5.0 um pore size PVC filters with gravimetric analysis. Aromatic hydrocarbon sampling and analysis for toluene and xylene was conducted according to NIOSH Method 1501. The LOD for this set of analyses was 0.01 mg/sample.

Table 5

Total Organic Hydrocarbon Concentrations
Measured with the Hnu Photoionization Analyzer

Kemper-Tappan
Richmond, Indiana
HETA 82-354

October 20, 1982

Sample Location	Total Organic Hydrocarbon Concentration (ppm) Range
Edgebander	1 to 4
Door Assembly	6 to 10
Omega Door Assembly	30 to 300
Primary Assembly	1
Door Finishing	
wiping stain	1 to 50
spraying stain	2 to 6
spraying sealer	3
spraying top coat	5 to 10
drying oven	2 to 4
Case Finishing	
spraying stain	3 to 5
spraying sealer	10 to 100
spraying top coat	10 to 20
drying after sealer	7 to 20
drying after top coat	100 to 150
Hand Sanding	4
Final Assembly	1 to 2
Touch-Up Finishing	10 to 200
Mix Building	50 to 70

Table 6

Personal Exposure Samples for Aromatic Hydrocarbons, Methyl Ethyl Ketone, Isobutyl Ketone, and Alcohols
Richmond, Indiana
HETA 82-354

September 27-30, 1983

Date	Job Oper./Area	Sample Time (min.)	Sample Volume (Liters)	Toluene (ppm)	Xylene (ppm)	MEK (ppm)	MIBK (ppm)	Butanol (ppm)	Isobutanol (ppm)	Isopropanol (ppm)
9-28	Edge Bander	420	20.7	0.06	ND*					
	Edge Bander	447	24.1	0.05	ND					
9-29	Door Finisher	470	22.2	0.66	17.65	ND	11.00			
	Door Finisher	474	24.2	0.50	12.45	2.45	3.78			
	Stain Sprayer	470	21.2	1.45	5.05			0.05	0.02	0.04
	Case Finisher	440	18.8	16.40	22.10	ND	1.90			
	Case Finisher	435	23.9	15.00	3.70	9.60	14.10	0.08	0.16	0.15
	Case Finisher	405	20.1	16.60	2.10					
	Door Finisher	341	16.3	0.73	2.30	ND	ND			
	Door Finisher	335	21.4	13.10	4.20					
	Pump House Oper.	328	13.7	15.60	7.20			0.09	0.06	0.09
	Expeditor	442	20.8	ND	0.11			ND	ND	ND
	Inspector/wrapper	431	20.6	0.71	ND	ND	ND	ND	ND	ND
	Topcoat Booth-Area#	343	17.2	5.00	13.20			0.16	0.07	ND
	Pumphouse-Area#	320	15.7	16.20	5.40					
	Pumphouse-Area #	347	18.2	2.40	3.30					
9-30	Case Finisher	431	21.4	0.06	0.32					
	Case Finisher	418	21.2	4.50	1.40			0.09	0.07	0.02
	Printer Oper.	427	22.1	0.06	0.21					
	Drawer Builder	407	23.0	ND	ND	ND	ND	ND	ND	ND
	Inspector/Touch-up	453	19.6	2.10	0.12	ND	ND			
	Topcoat Sprayer	423	22.3					0.27	0.12	0.02

*ND = No Detectable Level
No entry in a column indicates that type of sample was not collected.
= Ambient air area samples, not personal exposure samples.

Sampling and analysis for aromatic hydrocarbons was conducted according to NIOSH Method 1501. The Limit of Detection (LOD) for this set of analyses was 0.01 mg/sample. Sampling and analysis for methyl ethyl ketone and methyl isobutyl ketone was conducted according to NIOSH Method 2500 (LOD = 0.03 mg/sample). Sampling and analysis for alcohols was conducted according to NIOSH Method 1400 (LOD=0.01 mg/sample).

Table 7

Personal Exposures to Nuisance Dust
Total & Respirable Portion

Kemper-Tappan
Richmond, Indiana
HETA 82-354

September 27-30, 1983

Date	Job Operation (wood type)	Sample Time (min.)	Sample Volume (Liters)	Nuisance Dust (mg/m^3) Total	Respirable
9/27	Tenoner #1 Operator (Oak)	452	768		0.13
	Tenoner #1 Operator (Oak)	444	682		0.12
	Tennon #4 (Particle Bd)	427	725		0.15
	Drill Operator (Particle Bd)	434	738		0.07
	Saw Operator (Pine/Hickory)	442	751		0.20
9/28	Feeder-Off Bearer	519	882		0.13
	Giben Saw Operator	480	816		0.15
	Take off from Sander (Oak)	434	737		0.16
	Gang Router (Oak/Cottonwood)	480	816		0.33
	Sander Operator (Oak)	470	799		0.44
9/28	Bandsaw Operator (Hardwood)	471	942	2.8	
	Feeding Sander	468	936	0.58	
	Shaper Operator (Hickory/Oak)	466	932	2.60	

Table 7 (continued)

Date	Job Operation (wood type)	Sample Time (min.)	Sample Volume (Liters)	Nuisance Dust (mg/m^3) Total	Respirable
9/28	Gang Router (Oak/Cottonwood)	479	958	0.44	
	Giben Saw Helper	439	878	0.83	
9-29	Sanding/Stacking Wall Units	424	720		0.10
	Install Drawer Guides	473	946	0.29	
	Door Hanger	435	739	0.14	0.05
	Picker Operator	418	710		0.14
	Warehouseman	377	754	0.34	
9-30	Sander (Speciality Items)	409	695		0.30
	Sander (Specialty Items)	409	695		0.23
9/30	Drilling Door Frames	457	773		NMA*
	Install Door Hinges	467	931	NMA	
	Picker Operator	502	976	NMA	NMA

*NMA = No measureable amount
Nuisance dust sampling was conducted using preweighed 37mm 50um pore size PVC filters with gravimetric analysis.
No entry in a column indicates that type of sample was not collected.

Table 8

Dust Concentrations (mg) in Various Size Ranges, ECD*

Kemper-Tappan
Richmond, Indiana
HETA 82-354

September 27-30, 1983

Sample Location (wood type)	Volume Sampled (m^3)	Total Wt.** Mass (mg)	Lower Size Cut-Off Category 9.0	5.8	4.7	3.3	2.1	1.1	0.7	0.4	Final Filter	Total <4.7
Next to Giben Saw #1 (Particle Bd)	13.5	7.95	4.1	1.7	0.7	0.4	0.4	0.0	0.1	0.3	0.4	1.6
Finish Mill Room Next to Tenoner #3 (Oak)	13.5	9.74	6.1	2.2	0.4	0.3	0.2	0.1	0.1	0.1	0.3	1.1
Between Tenoner #4 and Band Saw (Particle Bd/Oak)	13.5	13.4	9.4	2.4	0.1	0.6	0.4	0.0	0.1	0.1	0.4	1.6

*ECD - Size cut-offs in micrometers, effective cut-off diameter.
**Totals may not exactly equal sum of size categories due to rounding errors.