IN-DEPTH SURVEY REPORT:

CONTROL TECHNOLOGY FOR FORMALDEHYDE EMISSIONS

AT

Dixie Furniture Plant
Lexington, North Carolina

Report Written By:

Vincent D. Mortimer, Jr.

Date of Report:

December 11, 1984

Report No. 108-27b

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
Division of Physical Sciences and Engineering
Engineering Control Technology Branch
4676 Columbia Parkway
Cincinnati, Ohio 45226

PLANT SURVEYED:	Dixie Furniture Plant 411 S. Salisbury Street Lexington, North Carolina
STANDARD INDUSTRIAL CLASSIFICATION OF PLANT:	2435: Hardwood Veneer and Plywood 2436: Softwood Veneer and Plywood
DATE OF SURVEY:	November 15-19, 1982
SURVEY CONDUCTED BY:	Vincent D. Mortimer, Jr. Bruce A. Hollett Kenneth F. Martinez Alfred A. Amendola
EMPLOYER REPRESENTATIVES CONTACTED:	Mr. Sam Snyder, Personnel Manager Mr. Jack Leonard, Division Superintendent
EMPLOYEE REPRESENTATIVES CONTACTED:	no employee organization
ANALYTICAL WORK PERFORMED BY:	Robert Phillips, NIOSH/IWSB Utah Biomedical Test Laboratory Salt Lake City, Utah

INTRODUCTION

BACKGROUND FOR CONTROL TECHNOLOGY STUDIES

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency engaged in occupational safety and health research. Organizationally located in the Department of Health and Human Services (formerly Health, Education, and Welfare), it was established by the Occupational Safety and Health Act of 1970. This legislation mandated that NIOSH conduct a number of research and education programs separate from the standard setting and enforcement functions carried out by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards. The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study the engineering aspects of health hazard prevention and control.

Since 1976, ECTB has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques. Examples of these completed studies include the foundry industry; various chemical manufacturing or processing operations; spray painting; and the recirculation of exhaust air. The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures.

As in the past, current studies involve a number of steps or phases. Initially, a series of walk-through surveys is conducted to select plants or processes with effective and potentially transferable control concepts or techniques. Next, in-depth surveys are conducted to determine both the control parameters and the effectiveness of these controls. The reports from these in-depth surveys are used as a basis for preparing technical reports and journal articles on effective hazard control measures. Ultimately, the information from these research activities builds the data base of publicly available information on hazard control techniques for use by health professionals who are responsible for preventing occupational illness and injury.

BACKGROUND

This research study began as an assessment of occupational health hazard controls associated with the industrial use of adhesives. Plants in the aerospace, automotive, footwear, wood-products, and some other industries were visited to observe the relation of the workers to the use of adhesives in the manufacturing processes and the types of controls being used. This preliminary work identified hot-process veneering with urea-formaldehyde resin adhesives as the operation which could benefit most from control technology research.

Formaldehyde, a commonly used substance in industry and the life sciences, has long been recognized as a potential irritant of the eyes, nose, and skin. In the last few years, the results of some animal toxicity studies have shown a relationship between formaldehyde exposure and cancer in some laboratory animals. It is not known how long it will be until the risk of cancer for humans exposed to formaldehyde is determined. In the meantime, as a prudent public health measure, plants should reduce occupational exposure to formaldehyde as much as possible with engineering controls and work practices.

In response to this need, the Engineering Control Technology Branch of NIOSH is studying the control of formaldehyde emissions from hot-process veneering operations which use a urea-formaldehyde resin adhesive. The goals of this study are to evaluate a number of different approaches which some furniture/wood-panel manufacturing firms have taken to control these emissions, and then to disseminate useful information and practicable recommendations on effective methods for controlling occupational formaldehyde exposure.

The Dixie Furniture Company main plant was identified as one which had extensive measures to control formaldehyde emissions from hot-press veneering operations. The size of the ventilation system was impressive. In addition, this plant contained a radio-frequency heated press as well as two heated-platen presses. This in-depth survey was conducted to evaluate their operations and associated controls for formaldehyde exposure. This report documents the information pertinent to that evaluation.

GENERAL INFORMATION ABOUT THE PLANT AND PROCESSES

INTRODUCTION

At the time of the survey, the primary product of this plant was furniture, and a portion of the plant, referred to as the glue room, produced veneered panels used to make the furniture. The plant employed from 900 to 1100 people, approximately 90 percent of which were hourly production workers. The total number of workers assigned to the glue room was approximately 50, and less than 20 worked close to a hot press.

PROCESS

The simplest veneered panel consists of three plies, a face and a back veneer glued to each side of a core, although additional pairs of plies may be added. An established way to achieve a high rate of production is to reduce the glue-curing time by heating the glue while pressure is being applied to the panels. One way to do this is to heat the metal plates which apply the pressure, generally referred to as a "hot-press" process. Another way is to generate heat in the glue-line with radio-frequency (RF) radiation in much the same way that food is cooked in a microwave oven. In this "RF-press" process, the hydraulic press only applies pressure. "Cold-press" processes, those for which pressure is applied while the boards are maintained between 60° and 100°F, require much longer periods of time for the glue to cure.

For most applications, the glue which currently provides the best performance for the least cost is a urea-formaldehyde (UF) resin adhesive. The core may be veneer, particleboard ("chip-core"), fiberboard, or a piece of edge-glued solid-wood "lumber-core." Almost all particleboard and fiberboard are made with formaldehyde resin binders, and a formaldehyde resin glue may be used to assemble lumber-core. To improve the appearance of a panel, the core may be "banded" with solid wood edges prior to veneering. Here again, the adhesive may contain formaldehyde.

In this plant, hot-press veneering was accomplished on one of two steam-heated multiple-opening presses or an RF press. Multiple-opening presses are characterized by a series of heated, thick, metal plates, one above the other, which open for loading and unloading and close to apply pressure. Processing the panels through this type of press is facilitated by sandwiching the panels to be pressed between metal caul plates. The multiple-opening presses in this plant both had ten openings, although they were not the same size. RF presses are most often used to produce curved panels. The panels are pressed between wooden forms attached to the opposing sides of hydraulically actuated platens. One large cold press was situated between the small ten-opening press and the RF press. The layout of the room is diagrammed in Figure 1.

Hot-press production was averaging about 14,000 square feet per day at the time of the survey. The average daily glue-line square footage was approximately 48,000 ft^2; 10 percent of this was produced on the RF press. Less than a fifth of the panels produced were cold-pressed.

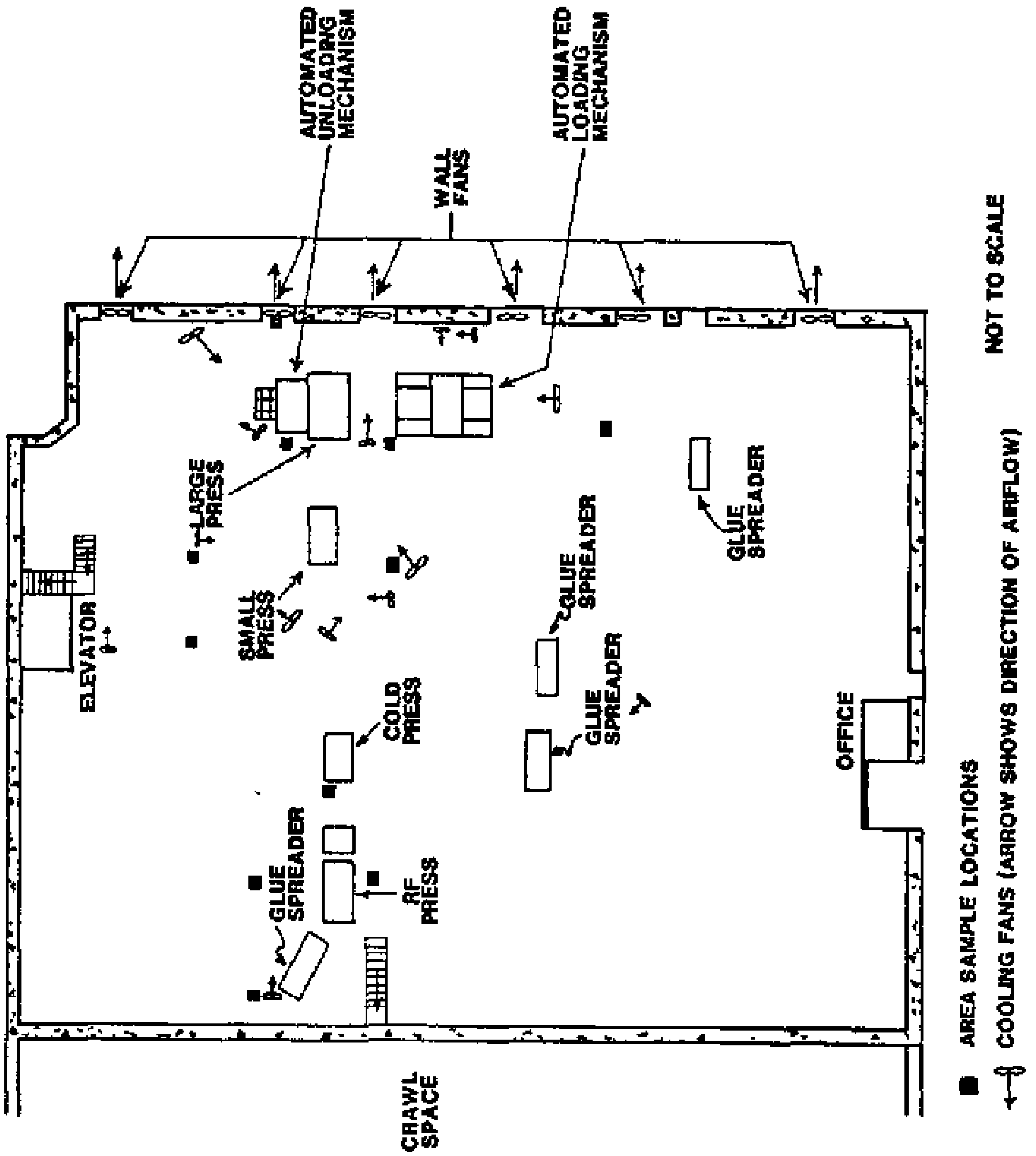

Figure 1. Panel Room Layout

POTENTIAL HAZARDS

In the hot-process pressing, formaldehyde is emitted while the boards are being pressed, although the escape of vapors seems somewhat restricted by the closed press. Consequently, much formaldehyde vapor is released when the press opens. The emission of formaldehyde from the hot boards continues as the boards are unloaded, stacked, and cooled. The primary route of exposure is inhalation.

The cold resin does not give off much formaldehyde; thus, mixing and spreading the glue and cold-press operations are not considered to be significant sources. Edge-gluing operations for making lumber-core and for banding, which are characterized by much smaller glue lines and more mechanization, are also not considered significant emitters of formaldehyde. There is the potential for dermal exposure during the glue-mixing, panel lay-up, and press loading operations.

Formaldehyde is a commonly used substance in many industries as well as in medicine and biology. Those who have been exposed to high concentrations of airborne formaldehyde can attest to its ability to make the eyes water and cause a burning sensation in the nose and throat.

This potential for irritation necessitates that formaldehyde exposure be limited to a few parts of the substance per million parts of air (ppm). The OSHA permissible exposure limit (PEL) is an 8-hour time-weighted average (TWA) of 3 ppm with a two-level ceiling limit up to 10 ppm for excursions above 3 ppm. However, from a review of known health effects and exposure levels completed in 1976, NIOSH determined that workers can still experience significant discomfort even while meeting these limits. Therefore, NIOSH published a "Criteria Document: Recommendations for an Occupational Exposure Standard for Formaldehyde" recommending that workers not be exposed to more than 1 ppm in any 30-minute period.

In the past few years, the results of experiments conducted by Battelle Columbus Laboratories for the Chemical Industry Institute of Toxicology and by New York University's Institute for Environmental Medicine, each lasting approximately 2 years, have linked formaldehyde to cancer in laboratory animals, at exposure levels higher than the OSHA standard. NIOSH reported these findings in "Current Intelligence Bulletin 34," published in April of 1981. In another recent study, conducted for the Formaldehyde Institute, no cancers occurred in animals exposed for 6 months to formaldehyde at 3 ppm and below under different experiment parameters. There has been considerable debate about the conclusions which should be drawn from these results.

But the fact remains that formaldehyde is a potent irritant; and, at this point, it cannot be discounted as a potential carcinogen. For this reason, NIOSH recommended in CIB 34 that, until the cancer risk to workers exposed to various levels of formaldehyde is determined, as a prudent public health measure, occupational exposures should be controlled to the lowest level feasible with engineering controls and good work practices.

METHODOLOGY

Air movement and airborne formaldehyde concentrations were measured to evaluate the effectiveness of the controls. Table 1 lists some of the major pieces of equipment used.

Table 1. Equipment Used on Field Surveys.

Item	Model	Used for
Hot-wire anemometer	Kurz model 441	Air velocity
Hot-wire anemometer	TSI model 1650	Air velocity
Pocket anemometer	Kurz series 480	Air Velocity
Pitot tube	2-ft x 5/16 OD	Air velocity pressure
Inclined manometer	Dwyer 0 - 1 in.	Air velocity pressure
Personal sampling pump	MDA 808	personal twa* samples
Personal sampling pump	DuPont P-200	area twa* samples
Organic vapor monitor	CEA-555	continuous monitoring
Detector tubes	Dräger 0.5a	short-term samples

* time-weighted average

MEASUREMENT OF CONTROL PARAMETERS

The volumetric flow rate through each of the ventilation ducts entering and leaving the press room was measured by performing traverses with a pitot tube or hot-wire anemometer. The airflow from the supply-air system was also checked by measuring the velocity of the airstream from each of the outlets with a hot-wire anemometer. The volumetric flow rate through the wall fans was estimated by measuring the velocity of the airstream at the inlet face of the fans. For each fan, two 10-point traverses, 90° apart, were conducted with a hot-wire anemometer. The airflow into each canopy hood was estimated by measuring the average velocity at the face of the exhaust ducts with a hot-wire anemometer. Air movement at various points in the vicinity of the canopy hoods and the work stations, through the doorways into the press room, and at other selected points in the press room was assessed by observing the flow of smoke from a smoke tube.

To determine daily personal exposures and average concentrations at selected points in the plant, personal and area samples for formaldehyde were collected using Supelco XAD-2 Formaldehyde Resin tubes and personal sampling pumps calibrated for a flow rate of approximately 50 milliliters of air per minute (ml/min). The solid sorbent tubes were analyzed for formaldehyde according to

NIOSH method P&CAM-354, a procedure involving desorption of a formaldehyde reaction product from the sorbent coating and analysis by capillary-column gas chromatography with flame ionization detection. The analysis was performed with the following modifications: the desorption solution contained 0.25 ul/ml hexadecane as an internal standard and the oven conditions were 8 minutes at 160°C, programmed at 32°C/minute to 200°C. A 25m x 0.20mm ID flexible fused silica Carbowax capillary column was used with a Hewlett-Packard Model 5711A gas chromatograph with a flame ionization detector. Helium was used as the carrier gas in the split mode of operation with a split ratio of 20 to 1. The analytical limit of detection for this method is typically 5 micrograms of formaldehyde per tube. Theoretically, sampling at the maximum rate (for this method) of 50 ml/min for over 6 hours should detect concentrations as low as 0.2 ppm.

All press workers in the press room were sampled, including those responsible for moving panels to be pressed into the press room and moving pressed panels to the cooling/staging area. Some area samples were spaced throughout the press room. One glue-spreader crew and the glue-mix man were sampled and an area sample collected at each of the two locations for these operations.

The daily results for each location category were averaged to obtain the results presented in Tables = - =. For those samples which were reported to be below the detection limit (BDL), either the detection limit (the value in parentheses in Tables A-1 and A-2) or half this value was used in computing the average concentration. If more than 50 percent of the values to be averaged were below the limit of detection, then the detection limit was used and the average is preceded by a "less than" symbol in the table. Otherwise, a value equal to half the detection limit was used as an estimate of the sample concentration.

The air at various points around the presses was analyzed for formaldehyde using a CEA-555 Organic Vapor Monitor to ascertain the order of magnitude of representative short-term formaldehyde concentrations. The CEA-555 continuously analyzes a sampled airstream for formaldehyde, employing a colorimetric procedure. Thus, this method is appropriate for evaluating short-term and ceiling exposures, but it has not yet been validated for determining compliance with standards. Also, only area samples were taken with this instrument on this survey. Therefore, these results should not be directly compared to any OSHA standards.

The standard "CEA 555-FO: Formaldehyde in Air" procedure was followed. The full-scale calibration for the CEA-555 that day was 1 part formaldehyde per million parts of air (ppm); the full-scale rise time for responding to the calibration input was approximately 4 minutes.

Some short-term samples for formaldehyde were also taken with colorimetric gas detector tubes. Some of these samples were taken close to the location of a CEA sample, but not necessarily at the same time. The tubes (Dräger 0.5/a) have a detection range of from 0.5 to 10 ppm. The manufacturer states that a standard deviation of 30 to 20 percent (relative to the mean, with the higher value corresponding to the lower range of measurement) be associated with this type of detector tube. Thus, this method only provides a rough estimate of formaldehyde concentration, not acceptable for evaluating compliance with any OSHA standards. It is, however, an appropriate method to determine approximate breathing-zone and area concentrations for the purposes of this study.

CONTROL TECHNOLOGY

INTRODUCTION: PRINCIPLES OF CONTROL

Occupational exposures can be controlled by the application of a number of well-known principles, including engineering measures, work practices, personal protection, and monitoring. These principles may be applied at or near the hazard source, to the general workplace environment, or at the point of occupational exposure to individuals. Controls applied at the source of the hazard, including engineering measures (material substitution, process/equipment modification, isolation or automation, local ventilation) and work practices, are generally the preferred and most effective means of control in terms of both occupational and environmental concerns. Controls which may be applied to hazards that have escaped into the workplace environment include dilution ventilation, dust suppression, and housekeeping. Control measures may also be applied near individual workers, including the use of remote control rooms, isolation booths, supplied-air cabs, work practices, and personal protective equipment.

In general, a system comprised of more than one of the above control measures may be required to provide worker protection under normal operating conditions and also under conditions of process upset, failure and/or maintenance. Process and workplace monitoring, personal exposure monitoring, and medical monitoring may be used to provide feedback concerning the effectiveness of the controls in use. The maintenance of equipment and controls to insure proper operating conditions and the education of and commitment from both workers and management concerning occupational health are also important ingredients of a complete, effective, and durable control system.

Not all principles apply to all situations, and their optimal application varies from case-to-case. The application of these principles at this plant are discussed below.

PRESS ROOM

Description

The presses were located in a basement room with a volume of approximately 100,000 ft^3. In addition to the presses, four glue spreaders (one for each press) and a supervisors office were located in the room. (Refer to Figure 1 for the layout of the room.)

In addition to the workers assigned to the presses and the glue spreaders, one worker moved stacks of cores, which would be used in laying-up panels to be pressed, from the elevator to the glue spreaders on the other side of the press room. To do this, he pushed the stacks on roller conveyors past the ten-opening presses. After the panels were pressed, this same worker moved the stacks of panels on another set of roller conveyers to the elevator to be taken to the staging area on the floor above the press room to cool and await further processing.

Controls

The primary control was a row of six wall fans, four of which were running during the survey. In addition, the multiple-opening presses were located under canopy hoods, and the RF press was surrounded by a ventilated enclosure. Two supply-air outlets had been installed in the unloading area of the large multiple-opening press. No make-up air other than the supply air was supplied to the room, resulting in a net deficit of approximately 100,000 cfm. The ventilation flow rates for the press room are summarized in Table 2.

Table 2. Press-Room Ventilation Flow Rates.

Ventilation Category	Volumetric Flow Rate, cfm
Total Exhaust	113,000
Local Exhaust Ventilation	21,000
General Ventilation	92,000
Total Make-up Air	2,000
Functional Supply Air	2,000
General Heating, Ventilation, & Air-Conditioning	none

Sampling Results

All time-weighted average concentrations were within the OSHA PEL—none exceeded 1.0 ppm averaged over the 3 days of sampling. (Refer to Appendix A, Tables A-1 & A-2 for the individual sample results.) Table 3 shows that the area concentrations for the unloading side of the presses were higher than for the loading side and that the area concentrations both for the cold press and for the glue spreading and mixing areas were somewhat lower.

Table 3. Press-Room and Adjacent Area Time-Weighted Average Concentrations.

Area	Number of Samples	Average Concentration ppm	Standard Deviation ppm
Glue Spreading and Mixing	9	0.14	0.03
Loading Side of Presses	12	0.23	0.33
Unloading Side of Presses	18	0.40	0.12
Cold-Press	2	0.15	0.01

Discussion

While it seems clear that the pressing operations and the stacks of hot boards are significant sources of formaldehyde, the full-shift TWA worker exposures at this plant were less than the OSHA standard. This was mostly due to the large quantity of air exhausted by the ventilation system. However, the lack of supplied make-up air caused a strong flow of air across the press room from the open stairways and the elevator shaft to the wall fans. This crossdraft seemed to be detrimental to the control of formaldehyde exposures.

Although it is difficult to individually assess each of the hot presses due to their being situated in a room with a strong crossdraft, there are some unique aspects of controlling each press. These are discussed in the following three sections.

LARGE TEN-OPENING PRESSES

Description

The large ten-opening press had both an automated loading mechanism and an automated unloading mechanism. Four workers were assigned to operate the press: two loaders and two unloaders.

While the previous load was being pressed, the loaders prepared the rack of the automated loading mechanism with a stack of triplets, each consisting of a caul plate, a layer of panels, and another caul plate--one triplet for each opening of the press. When the press opened, one of the unloaders operated the automated unloading mechanism, removing the triplets of newly pressed panels. Then one of the loaders activated the automated loading mechanism, inserting the next load into the now-empty openings.

Meanwhile, the unloaders were pulling the triplets from the rack of the automated unloading mechanism, separating the pressed panels from the caul plates, stacking the panels and standing the caul plates on edge on a wheeled plate rack. Then they moved the stack of panels to a holding area, pushed the rack of caul plates to the plate cooling area, and waited for the next load.

Controls

The canopy hood above the press extended 12 inches beyond the loading face of the press and, on the unloading side, approximately 40 inches out from the press. The hood, which had an open area of approximately 100 ft^2, exhausted an average of 13,000 cfm of air, yielding an average velocity of 130 feet per minute (ft/min) at the face of the hood. Although the top opening of the press was 63 inches from the floor, the canopy hood had to clear an automated mechanism on each side. On the loading side of each press, the lower edge of the hood was 82 inches high, and, on the unloading side, 93 inches.

Both supply-air outlets for the unloaders were located approximately 8 ft above the floor and 2 1/2 ft beyond the side edges of the caul plates. For one unloader, the supply-air outlet was approximately 2 1/2 ft beyond the end of the unloading platform; for the other unloader, approximately 4 ft. The closer one had a volumetric flow rate of approximately 1400 cfm, the other, approximately 500 cfm. Each had an average exit velocity of over 2000 ft/min.

Sampling Results

Table 4 shows that the average personal and area TWA concentrations were less than 1 ppm. Continuous sampling at various areas around the large multiple-opening press showed levels generally less than 3 ppm, except immediately in front of the input openings and around the unloading operations, for which levels greater than 5 ppm were recorded. Personal breathing-zone detector-tube samples of the unloader operating the automated unloading mechanism (a potentially high-exposure activity) showed exposures greater than 4 ppm—one sample indicated that the exposure may exceed 10 ppm. This activity, lasting about 30 seconds, was repeated about every 5 minutes for this worker. Breathing-zone detector-tube samples for the unloaders indicated short-term exposures between 1 and 10 ppm.

Table 4. Large Ten-Opening Press Time-Weighted Average Personal and Area Concentrations.

Grouping	Number of Samples	Average Concentration ppm	Standard Deviation ppm
Loading Areas	6	0.34	0.44
Loaders	6	0.21	0.07
Unloaders	6	0.50	0.18
Unloading Areas	12	0.50	0.48

Discussion

Airflow around the press and the workers was dictated primarily by the flow of air across the press room from the stairways and elevator shaft to the wall fans. The exhaust flow rate of the canopy hood was sufficient to contain the heated air rising into the canopy and to capture air a few inches beyond the edge of the hood for much of the perimeter, but much of the formaldehyde-laden air from the hot panels was not captured by the hood. Moreover, this press was downwind of the small multiple-opening press, so some of the airborne formaldehyde around this press and its workers probably came from the other press.

The placement of the supply-air outlets was such that their airflow was not directed through the breathing-zones of the workers while performing the potentially high exposure tasks. Instead, airflow for each of the workers was dominated by crossdrafts from small cooling fans as well as the ambient airflow. One cooling fan was placed on a table such that a stack of newly pressed panels was between the fan and the worker it was blowing on. The exit velocities from the supply-air outlets, approximately 2000 ft/min, were sufficient to maintain air velocities in excess of 200 ft/min up to 20 ft from the opening. However, there was little observable effect from the supply-air outlets on airflow in the breathing zone for the unloaders.

The automated loading and unloading mechanisms lessened the loaders exposures by allowing them to perform the majority of their job tasks approximately 10 ft away from the press. However, one unloader received a high peak exposure because he had to stand close to the press to push the button which operated the unloading mechanism.

SMALL TEN-OPENING PRESSES

Description

For the small ten-opening press, neither the loading nor the unloading process was automated. Four workers are required to operate the press: two loaders and two unloaders.

While the previous load was being pressed, the loaders prepared a stack of triplets, each consisting of a caul plate, a layer of panels, and another caul plate--one triplet for each opening of the press. When the press opened, one loader pushed out the triplets of newly pressed panels. Then the loaders inserted the next load into the now-empty openings. After the press has been loaded and activated, and information about the current load of panels had been recorded on the production log, they began preparing the next load.

Meanwhile, the unloaders had helped to remove the triplets from the press and pushed the mobile unloading platform approximately 20 ft from the press. At this location, they separated the pressed panels from the caul plates, stacked the panels and stood the caul plates on edge on a wheeled plate rack. Then they moved the stacks of panels to a holding area, pushed the rack of caul plates to the plate cooling area, and waited for the next load.

Controls

The canopy hood above the press extended 12 inches beyond the loading face of the press and 44 inches out from the unloading face. The hood, with a total open area was approximately 50 ft^2, exhausted an average of 6000 cfm of air, giving an average velocity of 120 ft/min at the face of the hood. On the loading side, the lower edge of the canopy was located just above the level of the top opening, 63 inches from the floor. On the unloading side, the lower edge was approximately 80 inches from the floor to allow unimpeded access to the unloading area.

Sampling Results

Table 5 shows that the average personal and area TWA concentrations were less than 1 ppm. Continuous sampling at various areas around the small multiple-opening press showed levels generally less than 1 ppm, except immediately in front of the input openings and around the unloading operations, for which levels greater than 5 ppm were recorded. Personal breathing-zone detector-tube samples of one loader "pushing-out" a load of pressed panels (a potentially high-exposure activity) showed an exposure of approximately 10 ppm. This activity occupied approximately 1 minute out of every 20 for this worker. Breathing-zone detector-tube samples for the unloaders indicated short-term exposures between 1 and 3 ppm.

Table 5. Small Ten-Opening Press Time-Weighted Average Personal and Area Concentrations.

Grouping	Number of Samples	Average Concentration ppm	Standard Deviation ppm
Loading Areas	8	0.16	0.07
Loaders	6	0.27	0.13
Unloaders	6	0.50	0.14
Unloading Areas	16	0.31	0.25

Discussion

Airflow around the press and the workers was dictated primarily by the cross draft from the elevator and stairways. The exhaust flow rate of the canopy hood was sufficient to contain most of the hot air rising into the canopy, but insufficient to capture air beyond a few inches from the edge of the hood. The loaders were in the path of air flowing around and through the press, especially during the manual push-out operation.

The unloaders for this press seemed to benefit from the crossdraft. Pulling the mobile unloading platform back about 20 ft from the press to separate the panels from the caul plates placed them in the flow of clean (relatively formaldehyde-free) air from the elevator shaft. The flow of air functioned essentially like a directed supply air outlet, albeit to the detriment of the effectiveness of the other ventilation. Their full-shift TWA exposures were as high as the other unloaders probably due to their having to stand under the canopy close to the press to help pull the triplets from the press.

RF PRESS

Description

The RF press was operated by two workers: a loader and an unloader. The loader places the panels to be pressed between the forms attached to the platens of the press, closed the door of the enclosure, and activated the press. When the panels had been pressed, the unloader opened the enclosure door on his side of the press and removed the pressed panels. He placed then on a work table about 4 ft from the door and, using a template, marked the panels for a future production operation. Then he stacked the panels along side the work table and waited for the next load. If other workers were not available in the press room, the RF-press loader and unloader participated in the glue mixing and panel lay-up operations for this press.

Controls

The RF press was surrounded by a ventilated enclosure. The total exhaust rate for the enclosure was approximately 2300 cfm, yielding an average face velocity of 400 ft/min through an open doorway.

Sampling Results

Table 6 shows that the personal and area time-weighted average concentrations on the east side of the press were higher than those on the west side. Continuous sampling at various locations around the press, including near the press openings and at the work stations showed levels less than 1 ppm. Detector-tube samples collected in the unloaders breathing-zone while panels were being unloaded indicated levels less than 1 ppm to approximately 3 ppm.

Table 6. RF Press Time-Weighted Average Personal and Area Concentrations.

Grouping	Number of Samples	Average Concentration ppm	Standard Deviation ppm
Loading Area	3	0.13	0.06
Loader	3	0.19	0.03
Unloader	3	0.26	0.04
Unloading Area	3	0.25	0.16

Discussion

Except on the loading side, the general room airflow was not as prominent around the RF press. The loader stood in a mild flow from the stairway just beyond the press.

Some of this ambient airflow also came from a crawl space on the other side of the wall at this end of the room. Due to this infiltration of air caused by the deficit of make-up air, most of the formaldehyde contained by the ventilated enclosure of this press and exhausted into the crawl space was probably reintroduced into the press room.

CONCLUSIONS AND RECOMMENDATIONS

All sampling results were less than the OSHA standard, with the exception of a few short-term samples which were of the same order of magnitude as the excursion limits. None of the personal or area time-weighted average concentrations exceeded 2 ppm averaged over the 3-day sampling period, and only one was greater than 1 ppm. However, continuous and short-term sampling showed that peak exposures were not as well controlled, some being measured on the order of 10 ppm. These levels were achieved with primarily general ventilation, exhausting over 100,000 cfm from the press room. Daily production during this period averaged about 15,000 square feet of panels for the three hot-presses combined.

The automated loading mechanism on the large multiple-opening press probably lessened the exposure of the loaders by allowing them to stand approximately 10 ft away from the press while performing there job tasks. The TWA exposures for the loaders on this press were less than those for the loaders on the other multiple-opening press which did not have automated operations, although not significantly given the variability of the sampling results and differences in the exposure situations.

The automated unloading mechanism did relieve the loaders from potentially high short-term exposures from the pushing out operation; however, it added high peak exposures to the unloader who it had to stand close to the press to push the button to operate it. His short-term exposures, as measured with detector tubes, were as high as for the loader on the other multiple-opening press during the manual push-out operation. If this mechanism could be operated from a location further away from the press, it would be more effective as an exposure control.

The supply-air ventilation is an exemplary feature, although the two supply-air outlets in this plant were not properly placed. The breathing zones of the workers while performing their jobs are usually among those areas difficult to control with any type of exhaust ventilation. Supplying tempered air from properly positioned outlets above the workers cleanses their breathing-zone with fresh air and pushes air towards the local exhaust ventilation while reducing the heat stress from working around the press. The information currently available indicates these outlets should be placed directly above the workers.

Appendix A. Survey Sampling Data

Table A-1. Personal Samples.

Worker	Date mo/dy/yr	Sample Lot	Sample No.	Volume liters	Duration minutes	Concentration ppm
Large M-o Press Loader D	11/16/82	43	612	20.5	501	0.20
Large M-o Press Loader D	11/17/82	44	643	25.7	503	0.19
Large M-o Press Loader D	11/18/82	44	673	25.0	499	0.17
Large M-o Press Loader U	11/16/82	43	613	25.2	503	0.17
Large M-o Press Loader U	11/17/82	44	645	20.9	510	0.35
Large M-o Press Loader U	11/18/82	44	672	24.9	508	0.18
Large M-o Press Unloader D	11/16/82	43	614	25.3	506	0.71
Large M-o Press Unloader D	11/17/82	44	642	23.1	513	0.67
Large M-o Press Unloader D	11/18/82	44	675	23.7	483	0.24
Large M-o Press Unloader U	11/16/82	43	615	21.5	511	0.50
Large M-o Press Unloader U	11/17/82	44	641	23.8	518	0.49
Large M-o Press Unloader U	11/18/82	44	674	19.2	504	0.36
Small M-o Press Loader D	11/16/82	43	618	26.6	484	0.48
Small M-o Press Loader D	11/17/82	44	639	27.9	498	0.30
Small M-o Press Loader D	11/18/82	44	669	23.6	512	0.13
Small M-o Press Loader U	11/16/82	43	619	25.3	496	0.28
Small M-o Press Loader U	11/17/82	44	640	26.0	509	0.28
Small M-o Press Loader U	11/18/82	44	668	26.5	519	0.24
Small M-o Press Unloader D	11/16/82	43	616	25.2	494	0.65
Small M-o Press Unloader D	11/17/82	44	637	21.9	510	0.64
Small M-o Press Unloader D	11/18/82	44	671	24.3	517	0.44
Small M-o Press Unloader U	11/16/82	43	617	26.7	495	0.56
Small M-o Press Unloader U	11/17/82	44	638	19.9	509	0.36
Small M-o Press Unloader U	11/18/82	44	670	22.9	521	0.34
Core Stocker	11/16/82	43	603	20.3	471	0.16
Core Stocker	11/17/82	44	648	22.4	498	0.15
Core Stocker	11/18/82	44	680	21.9	498	0.14
R/F Press Loader	11/16/82	43	601	24.7	485	0.21
R/F Press Loader	11/17/82	44	635	27.8	514	0.21
R/F Press Loader	11/18/82	44	679	22.1	492	0.16
R/F Press Unloader	11/16/82	43	602	21.7	483	0.30
R/F Press Unloader	11/17/82	44	636	26.1	512	0.24
R/F Press Unloader	11/18/82	44	678	27.0	491	0.23

Table A-1. Personal Samples (continued)

Worker	Date mo/dy/yr	Sample Lot	Sample No.	Volume liters	Duration minutes	Concentration ppm
Glue Spreader Worker F	11/16/82	43	610	21.6	480	0.15
Glue Spreader Worker F	11/17/82	44	633	20.3	495	0.16
Glue Spreader Worker F	11/18/82	44	677	23.9	469	0.13
Glue Spreader Worker T	11/16/82	43	611	22.2	443	0.16
Glue Spreader Worker T	11/17/82	44	632	25.2	495	0.16
Glue Spreader Worker T	11/18/82	44	676	25.1	474	0.36
Glue-mix Worker	11/16/82	43	604	13.0	283	0.25*
Glue-mix Worker	11/17/82	44	634	25.7	514	0.12
Glue-mix Worker	11/18/82	44	682	23.7	484	0.13
Stock Puller	11/16/82	43	605	21.9	465	0.18
Stock Puller	11/17/82	44	644	21.0	501	0.22
Stock Puller	11/18/82	44	683	23.3	485	0.13
Elevator Operator	11/16/82	43	606	11.5	444	0.28*
Elevator Operator	11/17/82	44	646	22.4	498	0.16
Elevator Operator	11/18/82	44	681	21.8	496	0.14

* Pump malfunction, resulting concentration not representative of a full-shift time-weighted average.

Table A-2. Area Samples.

Location	Date	Sample		Volume	Duration	Concentration
	mo/dy/yr	Lot	No.	liters	minutes	ppm
M-o Press Area 2	11/16/82	43	630	21.4	446	0.15
M-o Press Area 2	11/17/82	44	654	25.6	511	0.12
M-o Press Area 2	11/18/82	44	696	24.4	487	1.24
M-o Press Area 3	11/16/82	43	623	21.2	450	0.26
M-o Press Area 3	11/17/82	44	651	24.0	511	0.13
M-o Press Area 3	11/18/82	44	697	22.7	483	0.14
M-o Press Area 4	11/16/82	43	627	23.3	448	1.78
M-o Press Area 4	11/17/82	44	653	27.2	513	0.13
M-o Press Area 4	11/18/82	44	695	25.4	488	0.12
M-o Press Area 5	11/16/82	43	629	23.1	452	0.14
M-o Press Area 5	11/17/82	44	657	25.8	506	0.40
M-o Press Area 5	11/17/82	44	660	26.3	505	0.38
M-o Press Area 5	11/17/82	44	647	22.8	495	0.36
M-o Press Area 5	11/17/82	44	649	23.8	495	0.39
M-o Press Area 5	11/18/82	44	694	26.4	498	0.75
M-o Press Area 5	11/18/82	44	690	22.7	473	0.17
M-o Press Area 5	11/18/82	44	684	23.9	498	0.81
M-o Press Area 5	11/18/82	44	685	24.9	498	0.71
M-o Press Area 6	11/16/82	43	626	22.2	435	0.19
M-o Press Area 6	11/17/82	44	658	27.0	490	0.19
M-o Press Area 6	11/18/82	44	693	27.7	504	0.21
M-o Press Area 7	11/16/82	43	628	20.4	435	0.17
M-o Press Area 7	11/17/82	44	659	27.0	491	0.23
M-o Press Area 7	11/18/82	44	692	22.2	505	0.14
M-o Press Area 8	11/17/82	44	664	21.0	478	0.15
M-o Press Area 8	11/18/82	44	691	27.5	509	0.11
R/F Press Loading Area	11/16/82	43	621	24.7	449	0.16
R/F Press Loading Area	11/17/82	44	655	24.4	519	0.17
R/F Press Loading Area	11/18/82	44	686	25.5	500	0.12
R/F Press Mixing Area	11/16/82	43	624	24.6	448	0.17
R/F Press Mixing Area	11/17/82	44	652	28.5	518	0.11
R/F Press Mixing Area	11/18/82	44	688	24.0	499	0.13
R/F Press Unloading Area	11/16/82	43	620	24.8	450	0.35
R/F Press Unloading Area	11/17/82	44	656	24.9	518	0.13
R/F Press Unloading Area	11/18/82	44	687	23.6	502	0.34

Table A-2. Area Samples (continued)

Location	Date mo/dy/yr	Sample Lot	No.	Volume liters	Duration minutes	Concentration ppm
Glue Spreader Area	11/16/82	43	622	23.7	447	0.13
Glue Spreader Area	11/17/82	44	650	24.3	477	0.13
Glue Spreader Area	11/18/82	44	698	23.3	456	0.13
Glue-mix Room	11/16/82	43	600	22.2	426	0.17
Glue-mix Room	11/17/82	44	663	23.7	494	0.13
Glue-mix Room	11/18/82	44	699	26.0	473	0.19
2nd Floor Storage Area	11/16/82	43	631	21.2	424	0.15
2nd Floor Storage Area	11/17/82	44	662	24.1	492	0.13
2nd Floor Storage Area	11/18/82	44	700	27.0	490	0.32
Cold Press Area	11/17/82	44	661	26.0	482	0.14
Cold Press Area	11/18/82	44	689	24.7	505	0.16