PRELIMINARY SURVEY REPORT:

CONTROL TECHNOLOGY FOR FORMALDEHYDE EMISSIONS

AT

Hoosier Panel
New Albany, Indiana

REPORT WRITTEN BY:
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DATE OF REPORT:
December 1, 1982

REPORT NO.:
ECTB 108-23a

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

PURPOSE OF SURVEY:	To observe the processes and associated controls for veneering wood panels using heated-platen presses, with emphasis on the factors affecting the control of formaldehyde emissions during these operations.
DATE OF SURVEY:	July 29, 1982
SURVEY CONDUCTED BY:	Vincent D. Mortimer, Jr. Bruce A. Hollett Alfred A. Amendola
EMPLOYER REPRESENTATIVES CONTACTED:	Omer Marcell, Director of Manufacturing Paul Schaffer, Manager Ed Jones, Superintendent
EMPLOYEE REPRESENTATIVES CONTACTED:	Merle Elliott, President, IBPAW Local 384
STANDARD INDUSTRIAL CLASSIFICATION OF PLANT:	2435: Hardwood Veneer and Plywood 2436: Softwood Veneer and Plywood
ANALYTICAL WORK PERFORMED BY:	Robert Phillips, NIOSH/IWSB

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency engaged in occupational safety and health research. NIOSH was formally created by the Occupational Safety and Health Act of 1970. This legislation--which also gave rise to the Occupational Safety and Health Administration (OSHA) in the Department of Labor--called for a separate organization, NIOSH, to provide for research and education programs related to occupational safety and health. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards.

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. However, little information is available on the relative effectiveness of available methods for controlling exposure to formaldehyde in manufacturing wood panels.

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 research is being conducted primarily by performing a series of in-depth field surveys, which are preceded by a number of preliminary surveys. This preliminary survey was conducted at Hoosier Panel on July 29, 1982 to assess their operations and associated controls for possible inclusion in the in-depth study phase of the project. The following report documents the information pertinent to that assessment.

GENERAL INFORMATION ABOUT THE PLANT

Hoosier Panel produces veneered panels to order for industrial customers such as furniture manufacturers and prefabricated kitchen cabinet suppliers. They use both "hot-press" and "cold-press" processes. The normal production level averages between 20,000 and 30,000 square feet of panels per day. Most of the panels are produced by the hot-press process. Production was running at about 75 percent of normal at the time of the survey.

For the most part, the facilities are housed in single-story, wooden structures. The largest of these encloses approximately 100,000 ft^2, including kilns and storage facilities. The area called the glue room--actually, it is not a room in that there are few interior walls separating it from other areas of the plant--occupies about a tenth of this building (see Figure 1). The glue-mix room for panel production is a mezzanine/attic room; its position is shown with dotted lines on the schematic. Some offices are located at the west end of this building; others are located in a separate building on the north side of the property. A break room, with vending machines, is located in the veneer building.

At the time of the survey, 131 employees were working at the plant, down from a normal work force of 250. Sixteen of these were assigned to the glue room, the department which makes the veneered panels. The employees are represented by the International Brotherhood of Pottery and Allied Workers (Local 384). Production work hours are from 7:00 a.m. till 3:30 p.m., with a half hour for lunch. Office personnel work from 7:30 till 4:00.

PROCESS DESCRIPTION

The simplest veneered panel consists of three plies, a face and a back veneer glued to each side of a core. Additional plies may be added to make a panel which is stronger and more stable dimensionally. 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 (R/F) radiation in much the same way that food is cooked in a microwave oven. "Cold-press" processes, those for which pressure is applied while the boards--and glue--are maintained between 60^o and 100^oF, 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 (U/F) resin adhesive. The core may be a sheet of veneer, particleboard ("chip-core") or 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

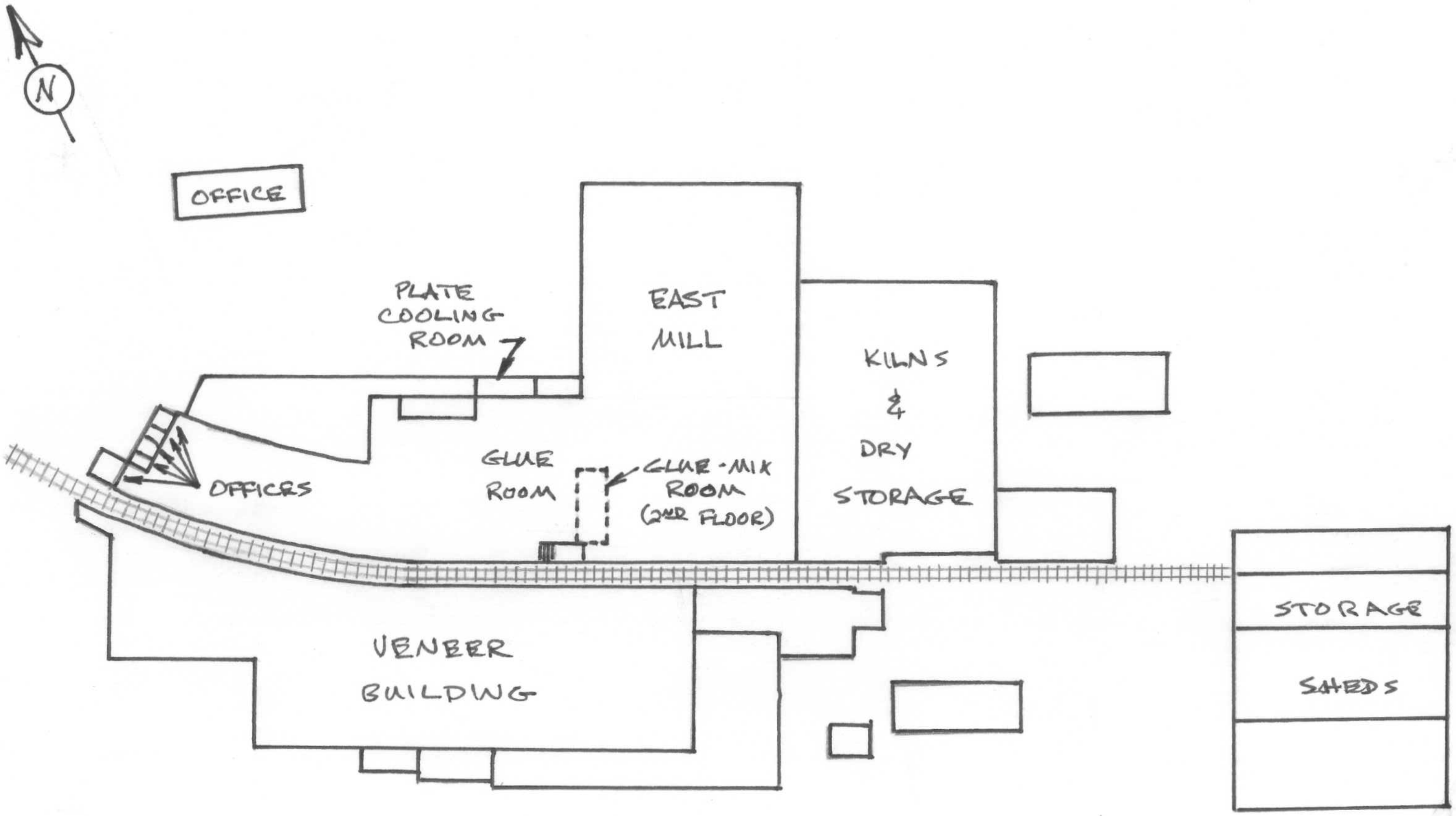

Figure 1 Layout of Plant

appearance of a panel, the core may be "banded" with solid wood edges prior to veneering. Here again, the adhesive may contain formaldehyde. A variety of hardwoods and softwoods, including oak, walnut, poplar, and pine, are used for veneer stock. Some plastic laminates are being used in certain products; usually these panels are cold-pressed.

The veneers are received in flitch form, thin strips bundled together as they were cut from the log. The veneer flitches are pressed, trimmed, and joined into sheets, which are then cut to the proper size for the panel being produced. The large panels of particleboard and fiberboard are cut into pieces of the appropriate nominal size. Hoosier Panel makes its own lumber-core, using its facilities for kiln-drying green lumber, surfacing the rough lumber, cutting the boards into thin strips, and edge-gluing these together into a continuous length which is then cut into pieces of the necessary size for core stock. The cores are then banded, if necessary, and trimmed to the desired size.

Hot-press veneering is accomplished on one of three steam-heated platen presses, operated at around 250^{o}F. There are two ten-opening presses, one five-opening press, and two glue spreaders located in the glue room. The decision of how many presses and spreaders to run is primarily determined by workload. Four workers are required to operate a press: two loaders and two unloaders. The procedures are intensively manual. As is typical for this type of press, processing the boards through the press is facilitated by sandwiching the boards to be pressed between metal caul plates.

The loaders prepare a stack of sandwiched, plate/layer of boards/plate triplets--one triplet for each opening of the press--while the previous load is being pressed. When the press opens, they partially push-out the triplets of pressed panels so the unloaders on the other side of the press can grasp them, remove them from the press, and stack them on a cart. Then the loaders insert the next load into the now-empty openings. After the press is loaded and activated, and information about the current load of boards has been recorded on the production log, they begin preparing the next load.

Meanwhile, the unloaders are separating the pressed panels from the caul plates, stacking the panels and standing the plates on edge on a wheeled plate rack. Then they move the stack of boards on roller conveyors towards the finishing area, push the rack of plates into the plate cooling room, and wait for the next load.

Hoosier panel has at least five different recipes for panel glue, all using Perkins L-100 urea-formaldehyde (U/F) resin. Perkins L-100 is a high solids (63-65 percent) urea resin with no more than 3 percent free formaldehyde. The principal hot-press formulations used at Hoosier Panel contain approximately 50 percent U/F resin, by weight. The other 50 percent of the glue is some combination of catalyst, water, extenders and fillers, and other additives. Wheat flour and shell flour are commonly used as extenders, and Perkins H-252 is the primary catalyst for hot-press glues.

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 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.

CONTROL MEASURES

A canopy hood is installed over each press, extending 10 to 12 inches beyond the sides of the press. Some of the slot openings have baffles, which may have been inserted to increase slot velocity. Each hood is vented through a 14- or 16-inch circular duct to a separate fan on the roof. These hoods have been in place for over 35 years. There are also some fans in the ceiling above the presses.

There are six wall fans in the plate cooling room, and some outside air is blown in through a grated floor. Since more air is exhausted from this room than is supplied from below, there is a net flow into the plate cooling room from the press area.

Airflow across the glue room is further aided by auxiliary fans positioned throughout the room and open doors and windows along the southwest wall. Some of these fans are hung from the ceiling in fixed positions, generally blowing towards the plate cooling room; the others are set on the floor, often blowing away from the plate cooling room. The fans, intended to cool the workers, may still be operated in cool weather due to the heat given off from a steam-heated press; but the doors and windows are closed when the influx of outside air is no longer desired. Other than in the plate cooling room, there is no make-up air supply.

OCCUPATIONAL HEALTH AND SAFETY PROGRAM

Hoosier Panel does not have an industrial hygienist, and routine air sampling in the plant is not performed. Having been requested by Hoosier Panel, an industrial hygiene survey of formadehyde levels was conducted in 1974 by Gulf Adhesives and Resins, then the supplier of the resin and additvies for H-P's panel glue. Workers compensation insurance is carried by American Mutual, but no industrial hygiene services have yet been provided by them.

Some of the workers in the glue room wear gloves and aprons. The glue-mix man wears an apron and, at certain times, goggles and gloves. A safety committee, comprised of section foremen and three union representatives, meets and inspects the plant monthly.

Emergency medical care is provided by the local hospital. Neither pre-employment physicals nor annual screening tests or examinations are given. Employee health and hospitalization insurance coverage is provided by Blue Cross/Blue Shield.

ASSESSMENT OF CONTROLS

Air Movement

Airflow at selected points was measured with a hot-wire anemometer and/or observed using a smoke tube. Measurable face velocities at the slot openings of the canopy hoods and thermal rise velocities along the faces of the presses were generally less than 100 ft/min. Thermal rise velocities and hood slot velocities measured on one side of one press not directly in the path of an auxiliary fan were approximately 100 ft/min, insufficient to capture air beyond the edge of the canopy hood. Theoretically, vertical air velocities driven solely by heat from the face of a press could approach 300 ft/min at the level of the uppermost platens.

By contrast, horizontal velocities on the order of 500 ft/min were generated across the faces of the presses by the auxiliary fans. Some of these fans blew air counter to the general flow, which was towards the plate cooling room; and, in some cases, they were positioned so that the breathing zone of some workers were downwind of a potential source of formaldehyde emissions.

CEA Sampling

The air at various points in the room was analyzed for formaldehyde using a CEA-555 organic vapor monitor to ascertain the order of magnitude of representative formaldehyde concentrations. The CEA formaldehyde determination is based on an established method using pararosaniline to generate a color change proportional to the amount of formaldehyde present in solution. Formaldehyde is first absorbed in a tetrachloromecurate solution containing sodium sulfite. After mixing with the pararosaniline reagent, the solution is analyzed for color intensity at 550 nm.

This method would be acceptable for evaluating short-term and ceiling exposures, but it has not yet been validated for determining compliance to 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 full-scale calibration for the CEA-555 that day was 2.72 parts formaldehyde per million parts of air (ppm); the full-scale rise time for responding to the calibration input was approximately 5 minutes.

Peak formaldehyde concentrations ranging from less than 1 ppm to between 1 and 2 ppm were measured on the loading side of press 1. This location was downwind of the press in the airstream of the small auxiliary fan blowing across the face of the press. The peaks were about 10 minutes apart. Between the peaks, the measured concentration fell to approximately 0.5 ppm.

Between presses 1 and 2, on the unloading side, the measured concentration did not rise above 1 ppm during a 20-minute sampling period. Further out from press 1, downwind of the separating boards and plates operation, a peak which exceeded the full-scale calibration of the CEA-555 was recorded. From examining the strip-chart record of the CEA output, it is estimated that the measured peak concentration would have been approximately 3 ppm.

Another peak exceeding the full-scale calibration of the CEA was recorded just after moving to the loading side of press 2, downwind of the press in the airstream generated by an auxiliary fan. This peak was slightly shorter in duration and may represent the opening of the press at the end of the pressing phase of the cycle. From looking at the strip-chart recording, it is estimated that the measured value of this peak would have been about 3 ppm. Non-peak values were around 1 ppm.

Detector Tube Sampling

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 (Draeger 0.5/a) had 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 to any OSHA standards. It is, however, an appropriate method to determine approximate breathing-zone and area concentrations for the purposes of this study.

No color change had taken place after 16 strokes for 3 samples: an area sample on the loading side of press 1, an area sample on the unloading side of press 1, and a breathing-zone sample near location 4 during the board/plate separation procedure. This complete lack of a color change may indicate a concentration less than 0.5 ppm. However, the noticeable formaldehyde odor at these locations points to defective samples in these instances.

For the other sample taken near the downwind corner of the loading side of press 1, the required color change was obtained in four strokes, corresponding to a measured concentration value of approximately 3 ppm. It was not noted which phase of the press cycle took place during the sampling period.

Two samples were collected near the downwind corner of the loading side of press 2 while the press cooled off and was loaded. Four pump strokes for one of these samples elicited the requisite color change, three strokes for the other, indicating approximately 3 or 4 ppm.

By comparison, a sample taken near a rack of cooling plates near press 2 and two samples collected a few inches from a stack of particleboard core-stock in the warehouse all developed a color match after four strokes, equivalent to 3 ppm. Although these were not breathing-zone samples, they demonstrate potential sources of formaldehyde exposure which should be included in the consideration of a control system.

CONCLUSIONS AND RECOMMENDATIONS

The primary methods of formaldehyde exposure control are dispersion, using auxiliary fans, and general ventilation. The local exhaust ventilation hoods over the presses are secondary to these other controls with respect to their contribution towards removing formaldehyde from the workplace. These hoods capture some of the emissions which rise from the edges of the heated platens, but the volumetric flow rate is insufficient to capture vapors beyond the boundary of the canopy openings.

With this arrangement and under the condition on the day of the survey, no sampling results were obtained which would indicate that full-shift time-weighted average exposures would exceed the current OSHA permissible exposure limit of 3 ppm. However, some short-term breathing-zone concentrations were measured in excess of 3 ppm. One reason for this may be that the air blown across the face of a press by the auxiliary fans interferes with thermal rise and moves horizontally large quantities of air which would otherwise have risen vertically into the capture zone of the canopy hoods. Another reason may be the formaldehyde given off by the hot boards while they are separated from the caul plates and stacked to await further processing. One of the objectives of our study is to address the problem of recurring peak exposures inherent with the discharge of hot boards from the press and their subsequent handling by the workers.

This plant offers the opportunity to study a unique approach to caul-plate cooling which also provides a large quantity of the general ventilation airflow. However, with no supplied make-up air, it is not known what effect the closing of doors and windows would have on the airflow within the plant. Moreover, it may be possible to position the auxiliary fans so that they contribute more effectively in controlling exposures.